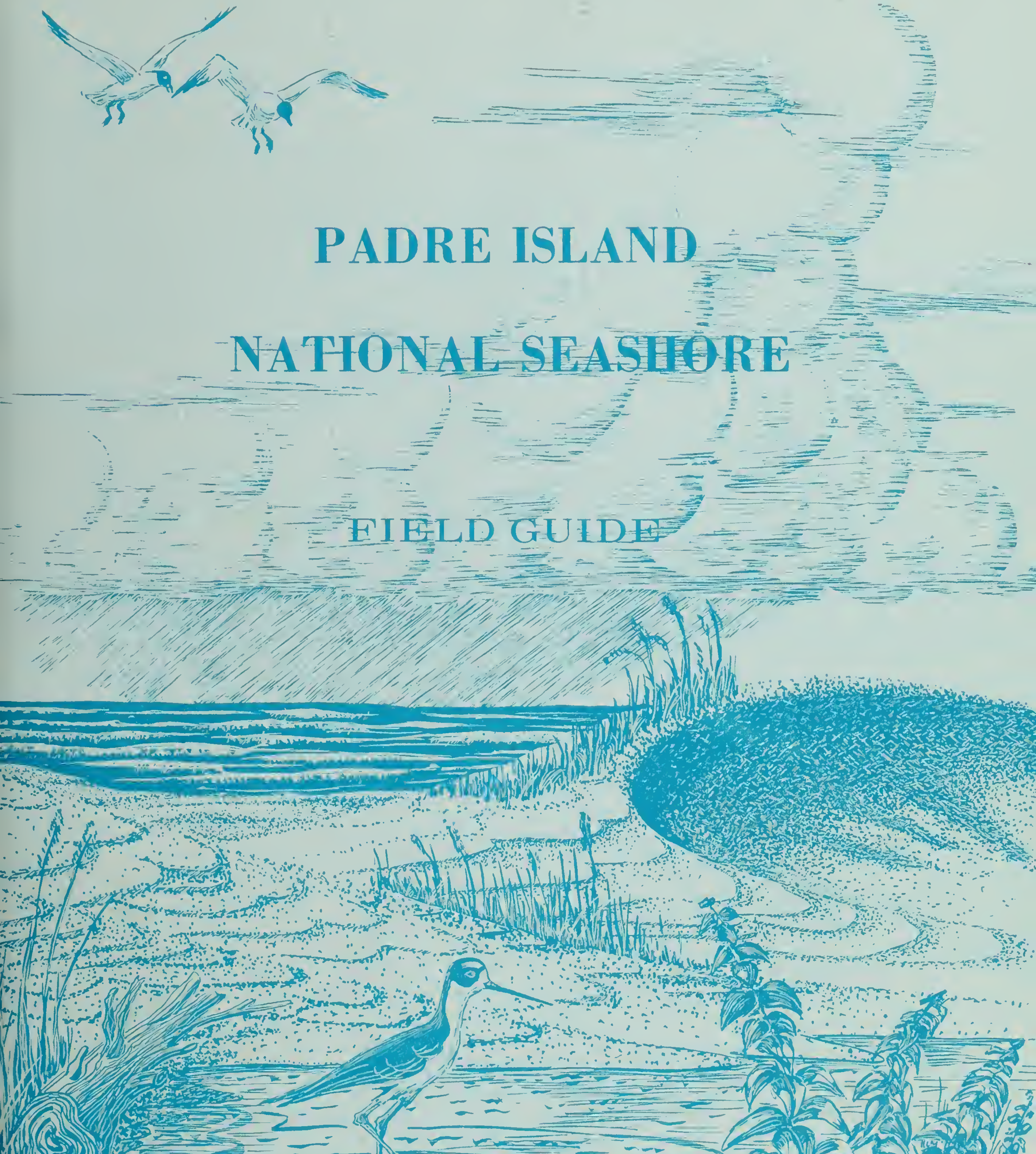
PADRE ISLAND

NATIONAL SEASHORE

FIELD GUIDE



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Padre Island National Seashore Field Guide

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INDEX

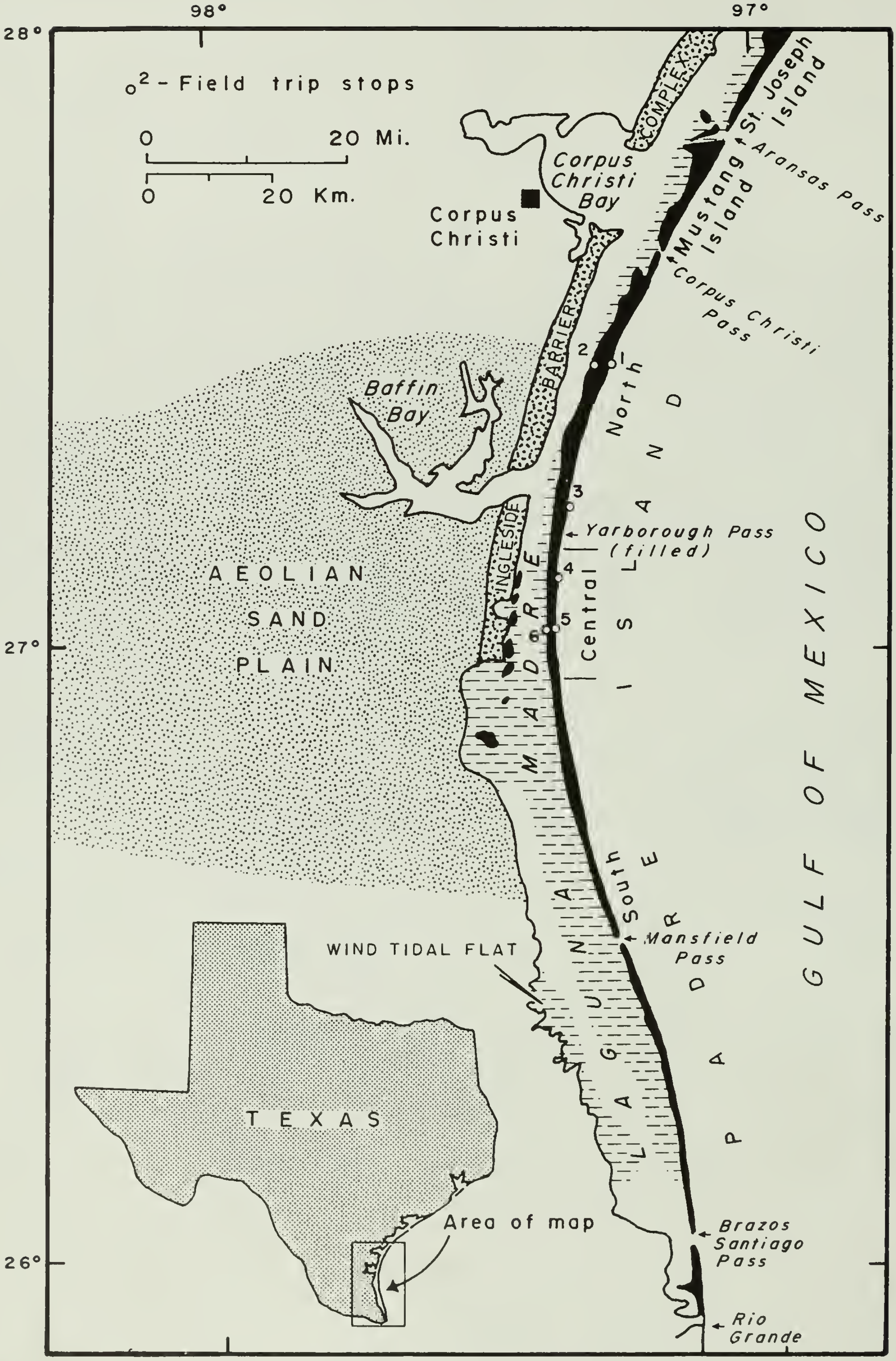

Fig. 1. – Location of Padre Island and the field trip stops.

MODERN DEPOSITIONAL ENVIRONMENTS AND PROCESSES, NORTHERN AND CENTRAL PADRE ISLAND, TEXAS[1]

Ralph E. Hunter[2], Richard L. Watson[3],
Gary W. Hill[2], and Kendell A. Dickinson[4]

ROAD LOG

Total mileage	Mileage from last reading	
0.0	0.0	Leave Malaquite Beach parking lot, Padre Island National Seashore, turning right (northeast) on Park Road 22.
3.7	3.7	Turn right (east) on beach access road near north end of Padre Island National Seashore.
4.2	0.5	STOP 1 on beach at north end of restricted beach zone. Because of the prohibition of vehicular traffic for 4.4 miles to the south, burrowing organisms of the beach have been able to attain their natural distribution and population levels. The beach is discussed on p. 6, the foredunes on p. 6. Just north of the beach access road is an active blowout dune field, shown in fig. 11; the active dune fields are discussed on p. 9. Return to Park Road 22 via beach access road.
4.7	0.5	Turn left (south) on Park Road 22.
5.2	0.5	Pass Grasslands Nature Trail. The northwest-trending grassed ridge is a stabilized longitudinal dune ridge left behind when the back-island active dune field passed over this area. The grassed flat is a deflation flat, formed by wind erosion of dune sand down to the level of damp sand.
5.8	0.6	Pass another stabilized longitudinal dune ridge, shown in fig. 2.
5.9	0.1	Turn right (northeast) on gravel road to oil storage tank.
6.5	0.6	STOP 2 at edge of back-island active dune field. Figure 2 is a map of the area. The active dune fields are discussed on p.9; the deflation flats over which you have just crossed are discussed on p.11. If conditions permit, drive across the dune field to the wind-tidal flats, discussed on p.13, and return to this point. Return to Park Road 22 via gravel road.
7.1	0.6	Turn right (south) on Park Road 22.
8.3	1.2	Pass Island Ranger Station.
8.7	0.4	Pass leading edge of an active blowout dune field which had advanced to the edge of the road in 1967. A pond was dredged to halt the advance of the dunes temporarily. Other active blowout dune fields can be seen along this road.
9.8	1.1	Pass Malaquite beach.
10.6	0.8	Turn right (south) on beach. For a distance of 3.3 miles, the foredune ridge is well developed except where active blowout dune fields are in contact with the beach.
13.9	3.3	For a distance of 3.5 miles, the foredune ridge that was present in 1948 has been extensively activated; the sand is now in the form of active dunes that are moving inland (northwestward). An attempt is under way to form a new foredune ridge by artificial planting.
16.9	3.0	Pass four-wheel drive warning sign. STOP 3 will be someplace in the next 9 miles, depending on local beach conditions. This section of beach is commonly called "Little Shell." For discussion see p. 23.
24.9	8.0	Pass Yarborough Pass, an artificial pass filled within a year after it was dredged.
25.9	1.0	STOP 4 will be someplace in the next 6 miles, depending on local beach conditions. This is the transition zone of the shell beaches. For discussions see p. 4.
31.9	6.0	STOP 5 will be someplace in the next 3.7 miles, depending on local beach conditions. This section of beach is commonly called "Big Shell." For discussion see p. 24.
35.6	3.7	Turn right on unimproved road to the abandoned Dunn Ranch headquarters.
36.2	0.6	STOP 6. Fig. 28 is a map of this area, which is typical of the central part of the island as discussed on p. 24. If conditions permit, return to the beach via the unimproved road along the back part of the island, stopping to look at the wind-tidal flats. After returning to the beach, return along it to the north.
62.2	26.0	Trip ends at Malaquite Beach.

INTRODUCTION

This trip furnishes an opportunity to observe landforms, sediment types, and sedimentary structures in two traverses across the island, one across the northern part and one across the central part (fig. 1). Along shore between these two localities, changes in beach morphology, sediment type, and shell types can be observed. One object of the trip is to observe features that will help geologists to identify coastal deposits in the stratigraphic record. Another object is to give trip participants an increased knowledge of environmental problems arising from man's use of the coastal region. We hope that all those who take the trip will enjoy the unique coastal environment preserved in Padre Island National Seashore.

PHYSICAL ENVIRONMENT

Padre Island is part of a curving chain of barrier islands and spits that stretches some 200 miles along the Texas coast from the Brazos River delta on the northeast to the Rio Grande delta on the southwest (fig. 1). Padre Island itself extends a distance of 110 miles without a permanently open natural pass; it is now divided by Mansfield Pass, which is artificially maintained. The wide separation of passes along the Texas barrier chain is characteristic of barrier island coasts having a low tidal range (Table 1), but another factor operating to deprive Padre Island of natural

[1]Publication authorized by the Director, U.S. Geological Survey
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TABLE 1. – Some geologically significant characteristics of the Texas coastal environment.

Environmental parameter		Brownsville – Brazos Santiago Pass	Corpus Christi – Aransas Pass	Galveston – Galveston Channel	Port Arthur – Sabine Pass
Mean diurnal tidal range, in feet[1]		1.4	1.7	1.4	1.9
Mean annual precipitation, in inches[2]		26.65	26.72	44.64	52.37
Resultant wind speed, in miles per hour, and direction[3]	January	2.7 from 130°	3.2 from 095°	3.0 from 071°	2.2 from 090°
	April	9.5 from 128°	8.8 from 125°	5.8 from 129°	5.7 from 153°
	July	11.0 from 140°	10.2 from 144°	7.8 from 186°	3.4 from 184°
	October	3.6 from 095°	4.9 from 090°	4.2 from 087°	3.2 from 074°
	Annual	6.0 from 127°	6.1 from 121°	not available	2.4 from 131°

[1] Data are for the tidal passes, from U.S. National Oceanic and Atmospheric Administration, National Ocean Survey, Tide tables, 1972, east coast of North and South America.

[2] Data are for the period 1931-1970, from U.S. National Oceanic and Atmospheric Administration, Environmental Data Service, Local Climatological Data, Annual Summary with Comparative Data, 1970, Brownsville, Corpus Christi, Galveston, and Port Arthur.

[3] Data from (1) U.S. Geological Survey, 1970, The National Atlas of the United States of America; (2) U.S. Weather Bureau, Climatography of the United States, No. 82-41 (Corpus Christi and Brownsville, 1951-1960) and No. 30-41 (Port Arthur, 1950-1955); (3) U.S. National Oceanic and Atmospheric Administration, Environmental Data Service, Local Climatological Data, 1967-1971, Port Arthur.

passes is the absence of large rivers emptying into Laguna Madre, which separates Padre Island from the Texas mainland (Phleger, 1969). Elsewhere along the Texas barrier chain, the large bays and rivers provide a sufficiently large tidal prism and fresh-water outflow to maintain about one open pass for each bay (Price, 1952).

On Padre Island, a larger role has been played by wind action in shaping the landforms and in transporting sand than on the more northeasterly part of the Texas barrier chain. Wind action has been important on Padre Island in part because of low rainfall and in part because the winds are strong and predominantly onshore (Table 1).

Hurricanes are another important geologic agent on Padre Island, as on other parts of the Texas barrier chain (Hayes, 1967; McGowen and others, 1970). During these storms, surges of high water wash over low parts of the island, eroding the beaches, cutting passes, and depositing sand as washover fans in Laguna Madre. Additional erosion of the passes occurs when the water pushed into the lagoon escapes to the Gulf during the waning stages of the storm. The passes cut by hurricanes are usually closed by sand deposition within a short time, but the healed passes remain low and are commonly reopened during subsequent hurricanes. Passes cut by hurricanes are abundant on the low narrow southern part of Padre Island but are uncommon along the central and northern parts where the island is wide and protected from wave attack by a vegetated foredune ridge typically more than 15 feet high.

Waves are the dominant force acting on the Gulf beach and shoreface of Padre Island. The wave energy is great enough, the sediment mobile enough, and the time of geologic activity has been long enough for the shoreface and inner continental shelf to approach an equilibrium form (Price, 1954a, b). The direction of longshore sediment transport is discussed in the section on longshore variations in beach sediment and origin of the shell beaches.

Geologically significant aspects of the Texas coastal environment have been discussed in more detail by Curray (1960) and Lohse (1955).

STRUCTURE AND AGE OF PADRE ISLAND

The Padre Island sand body overlies Pleistocene muds and sands. The top of the Pleistocene sequence is marked by a weathered zone in central Padre Island (Fisk, 1959) and by a shell layer in the South Bird Island quadrangle (Hunter and Dickinson, 1970); it is at a rather uniform depth of about 60 feet below sea level in the South Bird Island quadrangle, whereas farther south, in central Padre Island, it is only 25 to 50 feet below sea level (Fisk, 1959). The sand body continues to thin southward, and muds that are presumably part of the Pleistocene Rio Grande delta crop out locally on southern Padre Island (Rusnak, 1960). In cross section, the sand body is lenticular, grading seaward into Holocene marine muds that are probably very thin and grading landward into Holocene lagoonal muds and sands that pinch out at the mainland shore of Laguna Madre.

Radiocarbon dating of shells from Padre Island and

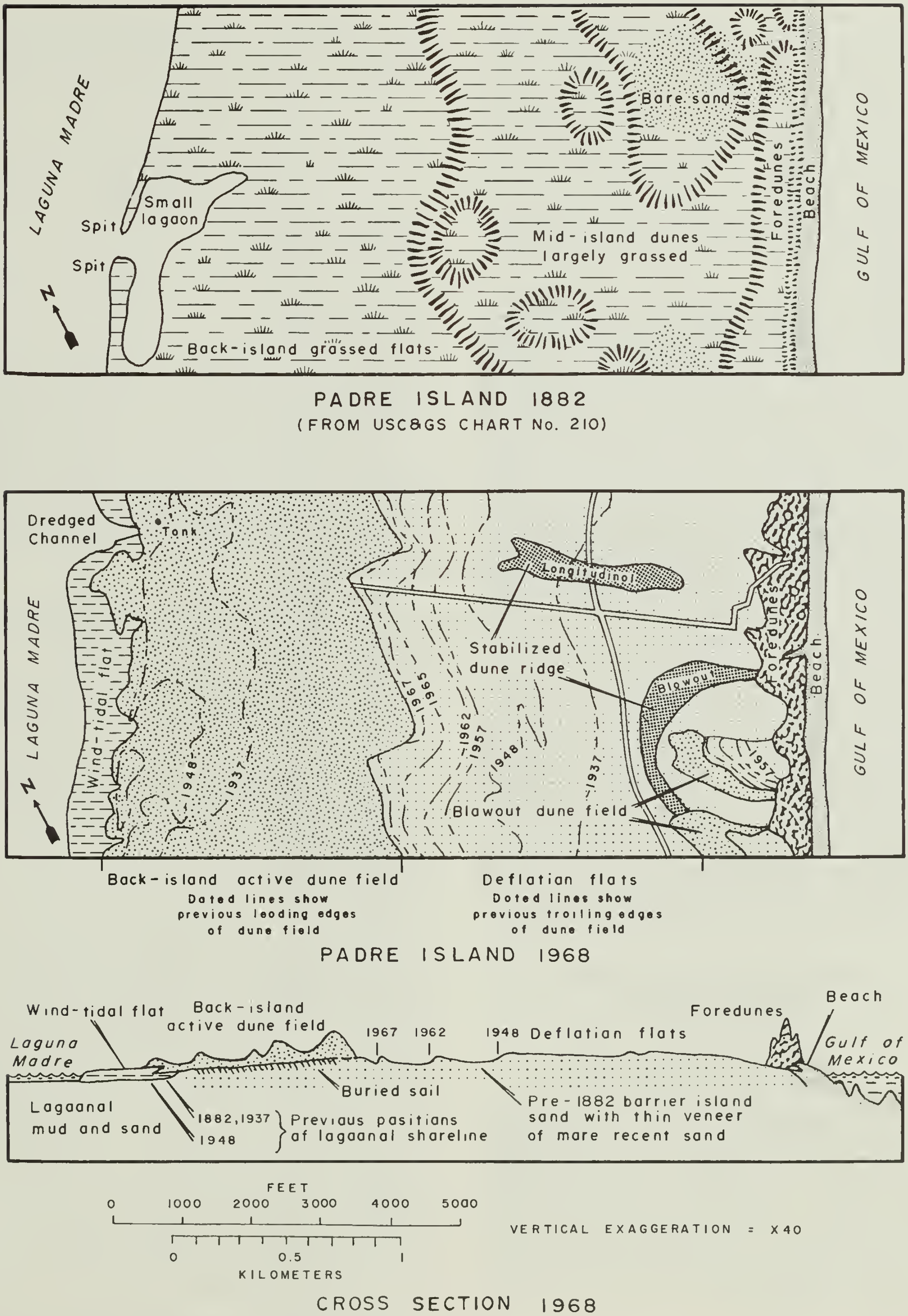

Fig. 2. – Changes in a typical part of northern Padre Island from 1882 to 1968. The mapped area is in the vicinity of the Chevron Plant, South Bird Island 7.5-minute quadrangle (Hunter and Dickinson, 1970) and is the locale for STOP 2 of this field trip. The scale applies to both maps and to horizontal distances on the cross section.

other barrier island sand bodies indicates that the barrier islands along the Texas coast began growing about 5000 years ago (Fisk, 1959; LeBlanc and Hodgson, 1959; Bernard and LeBlanc, 1965). By that time, sea level had risen to within 20 feet of its present level (Curray, 1960; Shepard, 1960). During the last few thousand years, some parts of the barrier chain have prograded seaward by the deposition of sand on their shorefaces, whereas other parts have remained stationary or have moved landward by shoreface erosion (Dickinson, 1971; Dickinson and others, 1972). On their landward sides, the islands have prograded into the lagoons by the deposition of sand washed or blown across the islands.

The long-term progradational nature of St. Joseph and Matagorda Islands, northeast of Padre Island, is shown by the presence of parallel beach and/or foredune ridges (McGowen and Garner, 1972). Such ridges are not present on Padre Island; but their absence is not necessarily indicative of a lack of progradation, for any ridges that once existed would have been destroyed by the extensive dune movement on Padre Island. The erosional nature of the Padre Island shoreline south of Mansfield Pass is shown by a comparison of the first accurate coastal charts, surveyed in the late 1800's, and maps surveyed in the period 1948-1955. Shoreline erosion of 1000 feet in less than a century can be documented in southern Padre Island. The Gulf shoreline of central and northern Padre Island has been relatively stable. No consistently measurable changes are evident from comparisons of the first U.S. Coast and Geodetic Survey chart surveyed in 1860-1882, aerial photographs taken in 1937, and recent maps and photographs; this condition of stability extends to about the southern limit of "Big Shell" beach, 30 miles north of Mansfield Pass. The vertical uniformity of the sand body in the northern part of the island, as shown by size analysis of drill-hole samples (Dickinson, 1971), suggests a stable Gulf shoreline since the origin of the island. Minor progradation may have taken place on central Padre Island, as suggested by exposures of shell gravel, probably a beach deposit, in depressions between dunes of the foredune ridge. This progradation, however, may have occurred at any early date in the island's history, long before the growth of the present foredunes, which form essentially a single ridge.

TRAVERSE ACROSS NORTHERN PADRE ISLAND

(STOPS 1 AND 2)

By Ralph E. Hunter, Gary W. Hill, and Kendell A. Dickinson

From its northern tip to a point 3 miles south of Yarborough Pass, Padre Island has a nearly invariant series of landforms arranged in zones parallel to shore. The South Bird Island 7.5-minute quadrangle, mapped by Hunter and Dickinson (1970), is typical of northern Padre Island and will serve as the locale for a traverse across the several geomorphic zones (fig. 2). The beach, foredunes, and an active blowout dune field can be seen at stop 1. The back-island active dune field, deflation flats, and wind-tidal flats can be seen at stop 2.

SHOREFACE

The sea floor beyond wading depth will not be accessible to participants of this field trip. Indeed, it is hardly visible even to divers using SCUBA because of the high turbidity usually found in the nearshore water. However, a short description of the shoreface will be given here because its deposits form an integral part of the barrier sand body.

The shoreface is a relatively narrow, steep, concave slope which grades seaward into a much wider, gently sloping, nearly planar surface that has been called a ramp (Price, 1954a, b). On a cross section of the Texas coastal plain and continental margin, the shoreface stands out as the steepest depositional surface of regional extent landward of the continental slope (fig. 3).

The nearshore part of the shoreface can be differentiated from the offshore part by the presence of a series of bars and troughs (fig. 4).

Offshore part of shoreface. – Seaward of the outer bar, the shoreface slopes away from shore without major reversals in slope direction. The bottom sediment consists of sand that decreases in grain size and becomes more clayey seaward (fig. 5). The transitional zone between sand and mud occurs on the lower part of the shoreface, at a depth of 45 to 50 feet. Mud and sand are thinly interbedded in the transitional zone, but burrowing organisms have partially mixed the sediments, thus producing mottled structures. The shell content of the sand is low, averaging only 0.8 percent.

The sand surface is rippled to the maximum water depth at which sand occurs on this part of the shelf. Starfish, sea pansies (*Renilla* sp.), sand dollars (*Mellita quinquiesperforata*), and polychaete worms are the most common benthonic species. Some faint bedding is present but, in general, the sand is nearly structureless because of intense bioturbation.

Nearshore bar-and-trough system. – North of the shell beaches on Padre Island, the nearshore part of the shoreface consists typically of a series of three bars and intervening troughs (fig. 4) whose contours are almost perfectly parallel to shore. Farther south, the bars are more commonly discontinuous and irregular in plan view, and the shoreline is marked by giant cusps. At times the bars are arranged en echelon, meeting the shoreline at very acute angles.

Bars of the type found along the Texas coast have commonly been called break-point bars, because waves break while passing over the bars. However, it is not clear whether breaking waves are directly responsible for the origin of such bars, as suggested by some wave-tank experiments (Keulegan, 1948; King and Williams, 1949; McKee and Sterrett, 1961), or whether the bars grow in response to hydrodynamic processes not directly related to breaking waves. The question is difficult to investigate in nature because the bars are equilibrium forms, moving back and forth with changing wave conditions but seldom growing from a previously planar bottom. However the bars originate, their maintenance as stable forms implies that sand must be carried seaward across the bars in amounts large enough to balance the amount carried landward by wave surge. How this equilibrium is achieved is a question more amenable to study than the question of bar origin, but a thoroughly satisfactory answer is not yet at hand.

Three kinds of sedimentary structures produced by waves and currents have been found in the bar-and-trough system of northern Padre Island. The most common

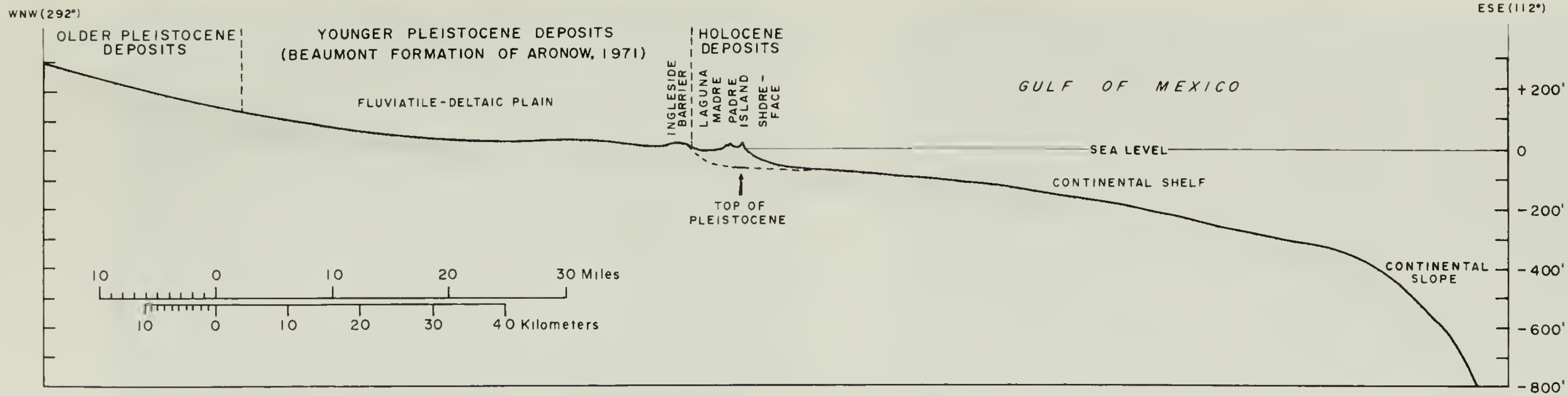

Fig. 3. – Cross section of part of Texas coastal plain and continental margin. The line of section is normal to shore, crossing the shoreline in the South Bird Island 7.5-minute quadrangle, near stop 2 of this field trip (See fig. 1). The thickness of Holocene deposits on the continental shelf is poorly known.

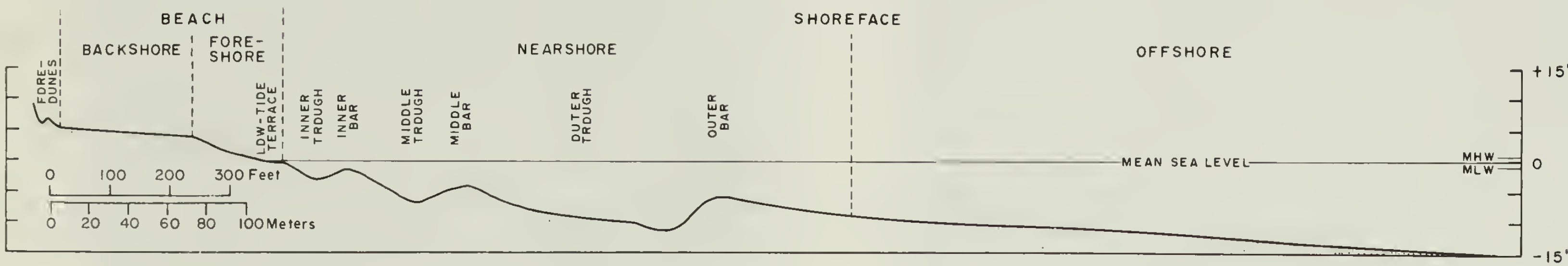

Fig. 4. – Profile of beach and shoreface. The morphology is typical of northern Padre Island during summer conditions. An ephemeral bar and runnel commonly replace the low-tide terrace. The part of the profile beyond wading depth was measured by fathometer.

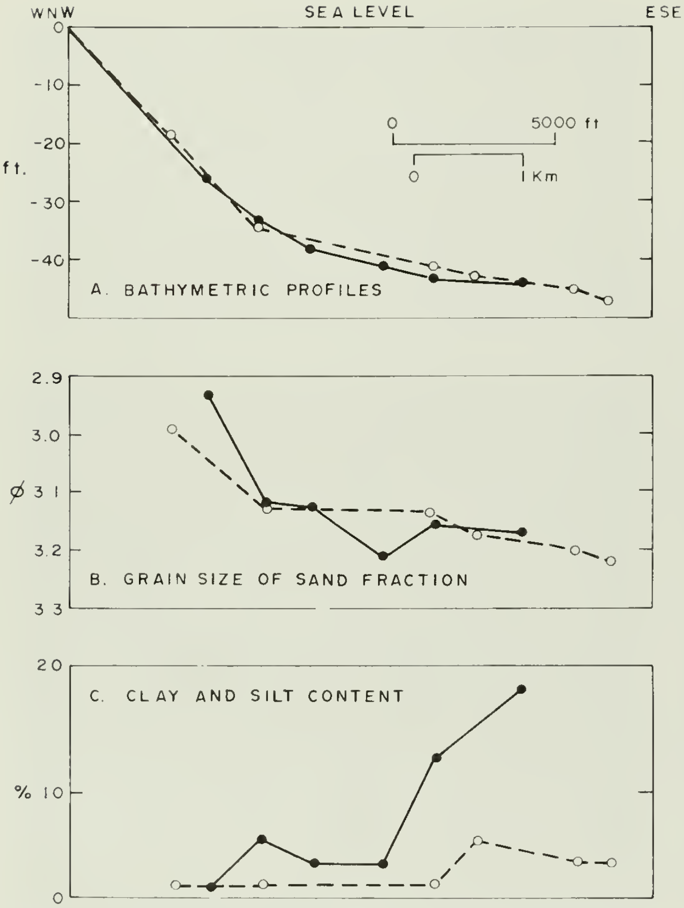

Fig. 5. – Variation in sediment texture across the shoreface of northern Padre Island. The two lines of samples are in the South Bird Island 7.5-minute quadrangle.

bedform is sand ripples. They tend to be aligned parallel to wave crests, are less than 2 cm in height, and are spaced 5 to 15 cm apart. Ripples in the troughs tend to be irregular in plan view, whereas those near the bar crests are straighter, lower, and more active in their response to wave surge. The internal structure produced by deposition on the rippled surfaces is small-scale lenticular crossbedding, usually without any well-defined preferred orientation of dip direction (fig. 6A). Whenever the waves are high enough to break on the bars, the bar crests are planar, and planar lamination is produced in the sand (fig. 6B). Whenever strong longshore currents flow in the troughs, megaripples ranging from 10 to 60 cm or more in height are formed. The internal structure produced by the migrating megaripples is medium-scale (units 4 to 100 cm thick) crossbedding that dips in the direction of the current (fig. 6C, D).

Current-produced sedimentary structures in the nearshore tend to be destroyed by burrowing animals. The burrowers can be divided into two broad groups based on gross burrow orientation. Species that produce deep vertical burrows are dominant in the inner nearshore, whereas species that burrow horizontally are more common in the outer nearshore. Ghost shrimp (*Callianassa*), which construct deep vertical burrows, are the dominant burrowing species throughout the nearshore. Sand dollars (*Mellita quinquiesperforata*), which burrow horizontally (fig. 7A), are abundant seaward of the middle bar. Common but less conspicuous horizontal burrowers and surface crawlers include the olive shells (*Oliva sayana, Olivella mutica*), moon shells (*Polinices duplicatus*) and auger shells (*Terebra cinerea*). Brittle stars and a variety of polychaetes produce burrows with both vertical and horizontal components (fig. 7B).

BEACH (STOP 1)

The form of the beach varies with changing wave conditions. Hurricanes and other severe storms produce especially striking changes, eroding the beach to a gently sloping planar surface (Hayes, 1967). The sand eroded from the beach during such storms is deposited in nearshore areas and is gradually carried back to the beach by normal wave activity. In its normal condition, the beach is made up of a nearly flat backshore, which, after its full development, is above the realm of normal wave activity, and a seaward-sloping foreshore washed daily by waves (fig. 4). A terrace near the low-tide line commonly separates the foreshore from the inner trough, although this terrace is often replaced by an ephemeral bar and runnel

The dominant internal structure of the beach is gently seaward-dipping planar lamination produced by wave swash (McKee, 1957; Milling and Behrens, 1966). As in the nearshore, however, burrowing organisms tend to destroy the primary structures and form their own distinctive structures. The ghost crab (*Ocypode quadrata*) is the dominant burrowing species on the backshore and upper foreshore. Variations in the areal density, size, and shape of the ghost crab burrows (fig. 8) can be used to define subenvironments of the beach (Frey and Mayou, 1971; Hill and Hunter, unpub. manuscript). The lower foreshore is dominated by the deep burrows of the ghost shrimp (*Callianassa islagrande*) (figs. 7C and 9). Within and especially between these two populations can be found large numbers of polychaetes (particularly *Heteromastis* sp.), mole crabs (*Lepidopa* sp., *Emerita* sp.), auger shells (*Terebra cinerea*), and the coquina clam (*Donax* sp.), which produce a variety of burrows (fig. 7C, D).

FOREDUNES (STOP 1)

Landward of the beach along most of northern Padre Island is a hummocky ridge of vegetated dunes, the foredunes, composed of sand blown from the beach by onshore winds. It is not definitely known whether the foredunes grew to essentially their present size before being stabilized by vegetation or whether vegetation was present from the very beginning of foredune development and was

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Fig. 6. – Sedimentary structures, produced largely by waves and currents, in the nearshore bar-and-trough system, northern Padre Island. The cores are 13 cm wide.

A. – X-radiograph of box-core peel from inner trough. Small-scale crossbedding formed by migration of ripples; down-bowing of bedding at edges of peel is artificial. B.– Box-core peel from inner bar. Planar bedding formed by deposition on planar bar crest; note vertical burrows. C.– X-radiograph of box-core peel from inner trough. Medium-scale crossbedding formed by migration of megaripples; the crossbedding dips northward, in the direction of the longshore current. D.– Box-core peel from middle trough. Small-scale crossbedding at top of section formed by migration of ripples, as in fig. 6A; planar bedding in middle may have formed by deposition on megaripple crest; crossbedding at base probably formed by migration of megaripple, as in fig. 6C.

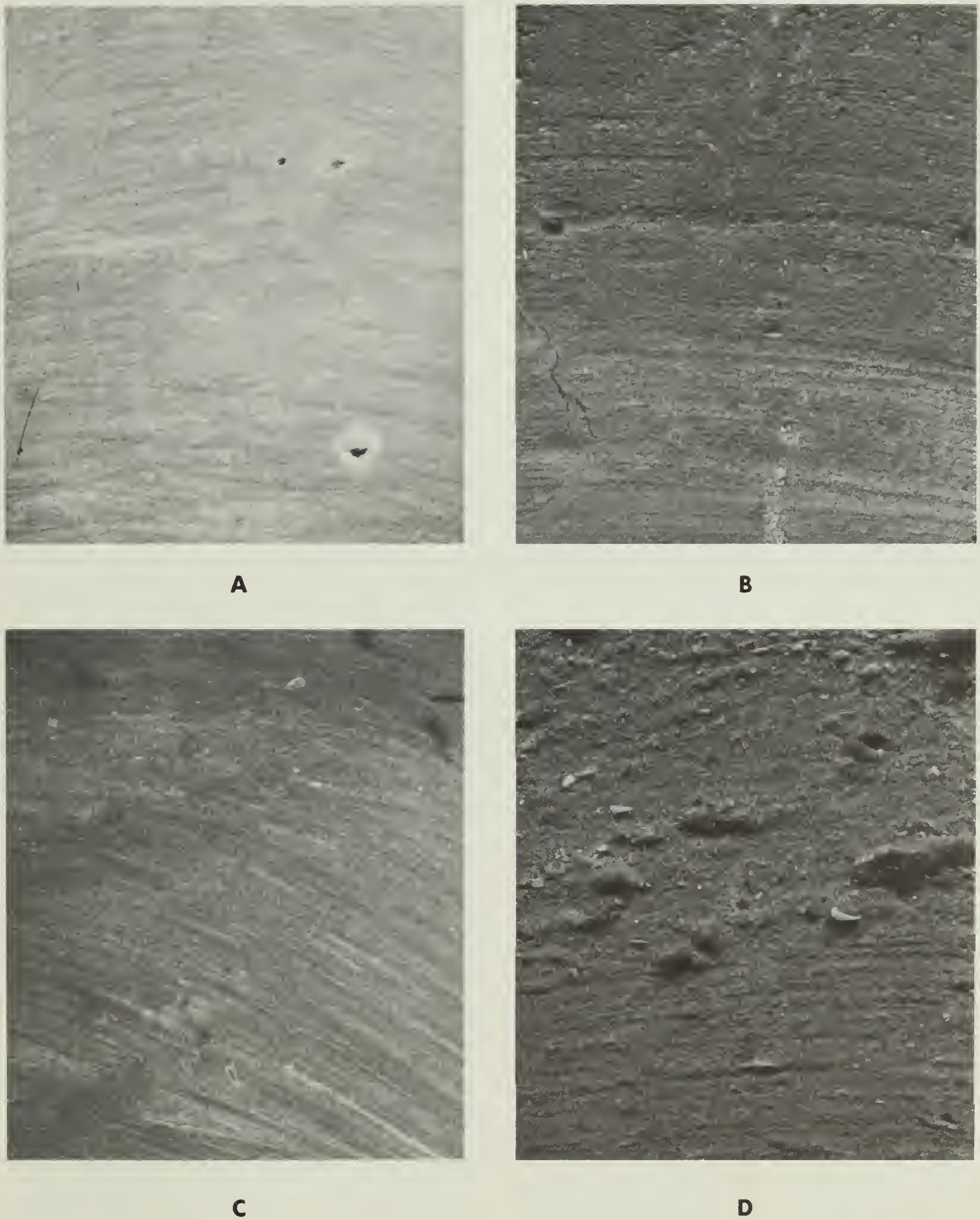


Figure 6

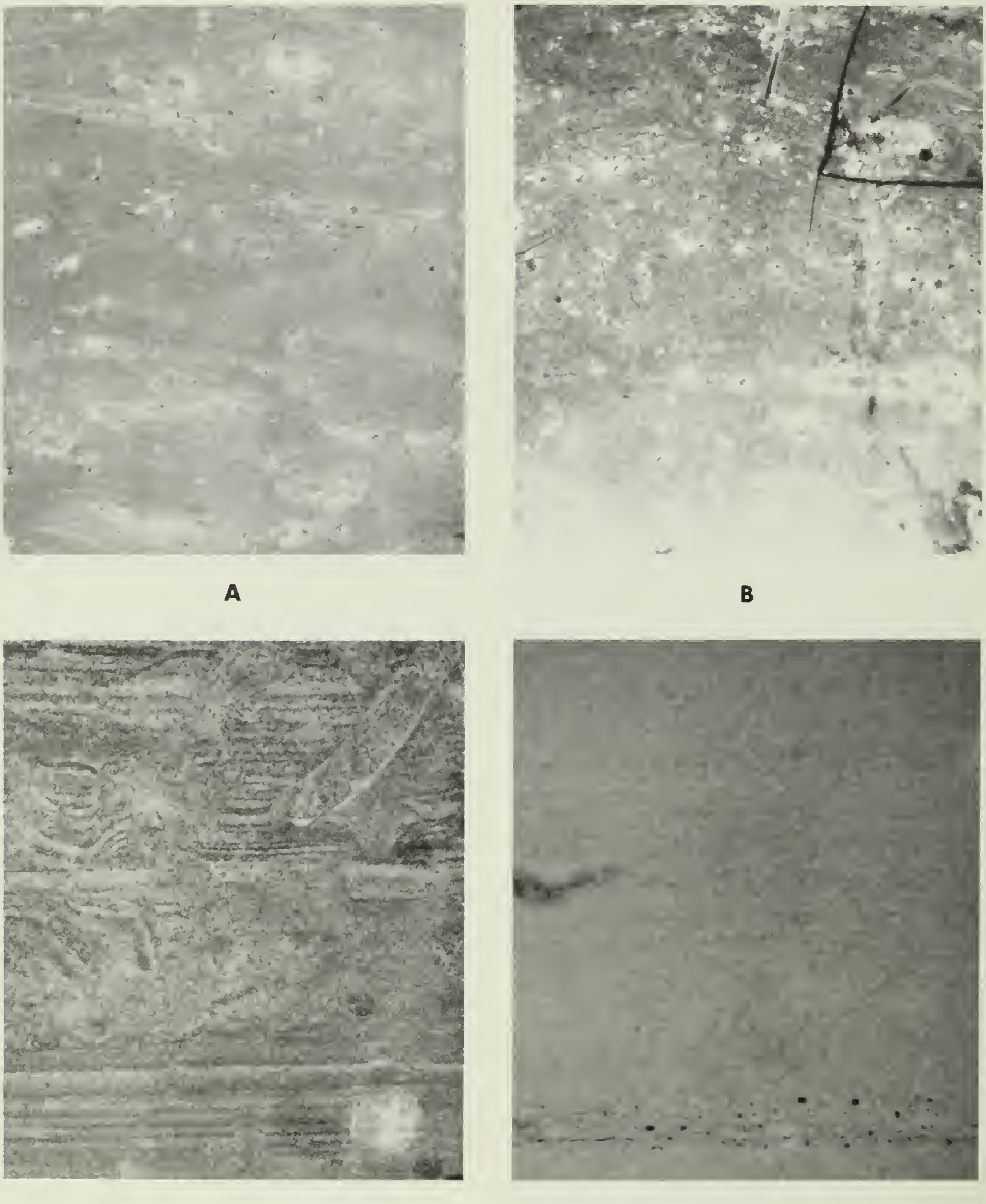


Figure 7

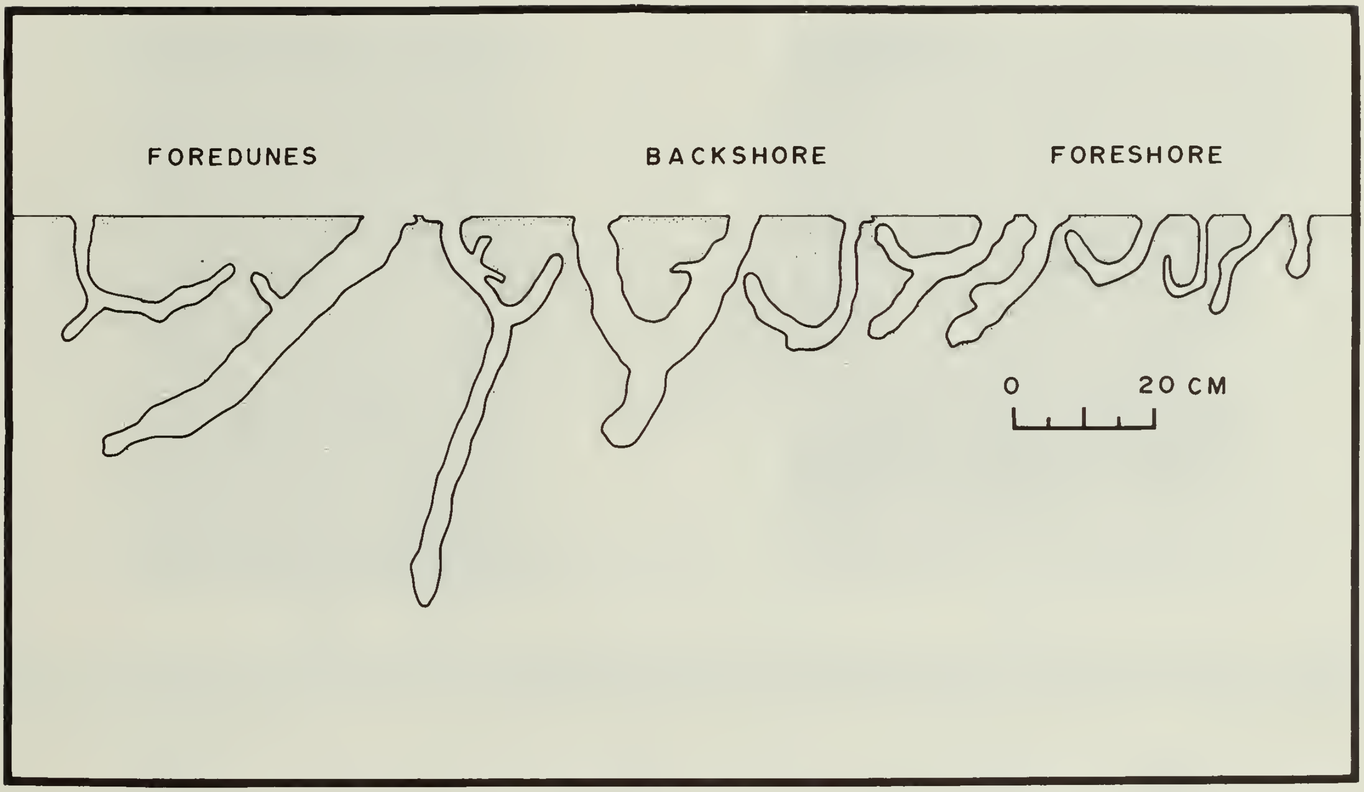


Fig. 8.– Representative ghost crab (*Ocypode quadrata*) burrows of a beach cross section, northern Padre Island (Hill and Hunter, unpub. manuscript).

directly responsible for trapping and binding the sand making up the dunes. Although the foredunes may have had less vegetative cover in the earlier stages of their development, it seems evident that they soon had enough vegetation to prevent them from migrating inland. Where the vegetative cover has been locally destroyed by drought, fire, overgrazing, or other disturbances by man, the dunes have been transformed into actively migrating forms that move inland and are thus no longer foredunes.

The dominant internal structure of the foredunes is medium-scale crossbedding. It dips predominantly in the downwind quadrant (northwestward), but two dip-direction modes are present, at angles to either side of the yearly resultant wind direction (McBride and Hayes, 1962; fig. 10B, F). This bimodality is related to the shapes of the foredunes; the individual mounds making up the foredune ridge typically have pointed or lobate leeward projections (fig. 10A), and as sand is deposited on the side slopes of these projections, bimodal crossbedding is produced. These leeward projections form in two ways, as wind-shadow accumulations leeward of vegetated dune mounds (Hayes, 1967) and as blowout dunes, which in plan view are typically parabolic and convex in the downwind direction.

Several kinds of biogenic structures occur in the foredunes. Most common is indistinct irregular bedding formed by the accumulation of sand around plants; bedding irregularity may also be produced by the growth and decay of plant roots. Several species of animals are responsible for a variety of burrows to be found in the foredunes. The ghost crab (*Ocypode quadrata*) is common, especially on the lightly vegetated seaward slope of the dune ridge. Other animals that excavate or utilize burrows in the foredunes include a variety of snakes, lizards, and rodents.

ACTIVE DUNE FIELDS (STOPS 1 and 2)

The dunes actively migrating across northern Padre Island at present have originated almost entirely by the devegetation of once-stabilized dunes. In a dry period beginning in 1948, for example, previously existing and newly formed small blowouts in the foredune ridge were greatly enlarged and began moving downwind (northwestward) (fig. 11). As long as the blowouts were connected to the beach by unvegetated sand, sand blown from the beach must have been added to the active dunes. In a few years, however, most of the blowout dune fields became separated from the beach by the formation of a vegetated foredune ridge and by newly vegetated deflation flats left behind the moving dunes. Very little if any sand is

Fig. 7. – Sedimentary structures, produced largely by burrowing organisms, in the nearshore bar-and-trough system and beach, northern Padre Island. The cores are 13 cm wide. A.– X-radiograph of box-core peel from outer bar. Abundant horizontal burrows in shelly sand, probably produced by sand dollars; original bedding largely destroyed. B.– X-radiograph of box-core peel from outer trough. Vertical and curved polychaete worm tubes, together with other burrows; original bedding largely destroyed; cracks are artificial. C.– X-radiograph of box-core peel from low-tide terrace. *Callianassa* burrow defined by cemented wall, other irregularly shaped burrows, and intensely bioturbated interval between intervals with partially preserved bedding; the planar bedding was formed by wash swash. D.– X-radiograph of box-core peel from backshore. Sand intensely bioturbated by small burrowing organisms, either polychaete worms or burrowing insects; note porous interval near base and remnant bedding.

A B

Fig. 9. – Burrows of the ghost shrimp (*Callianassa islagrande*). A.– Narrow, upper section of burrow and its junction with larger, main section. B.– Cast of main section of burrow. The large knob at top of burrow cast is artificial.

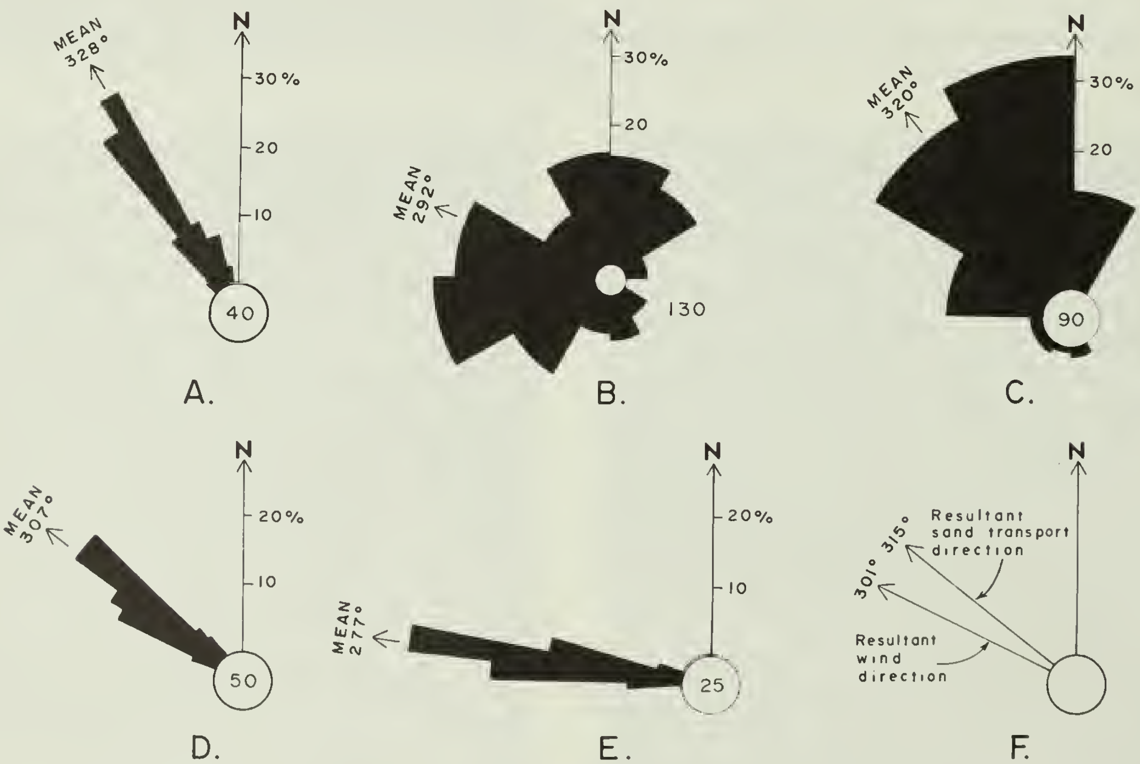


Fig. 10. – Rose diagrams showing orientations of wind-formed features. Measurements were made in the South Bird Island 7.5-minute quadrangle unless otherwise noted; number of measurements indicated within central circle of diagram. A.– Directions of elongation of blowouts, blowout dunes, and wind-shadow drifts in the foredunes; measurements from aerial photographs. B.– Dip directions of crossbedding in the foredunes, Mustang Island, Texas (McBride and Hayes, 1962). C.– Dip directions of crossbedding in the basal few feet of the back-island dune field. D.– Directions of migration of distinctive reentrants and salients in the blowout and back-island dune fields; measurements from aerial photographs. E.– Trends of large oblique dunes in the back-island dune field; measurements from aerial photographs. F.– Resultant wind and sand transport directions calculated from wind data collected during 1951-1960 at Corpus Christi. The relative sand transporting power in a given direction, Q, was calculated from the equation $Q = N(V-v)^3$, where N is the proportion of all wind observations that are in the given direction, V is the mean wind speed from the given direction, and v is the threshold wind velocity, here taken as 10 miles per hour (Boker, 1956).

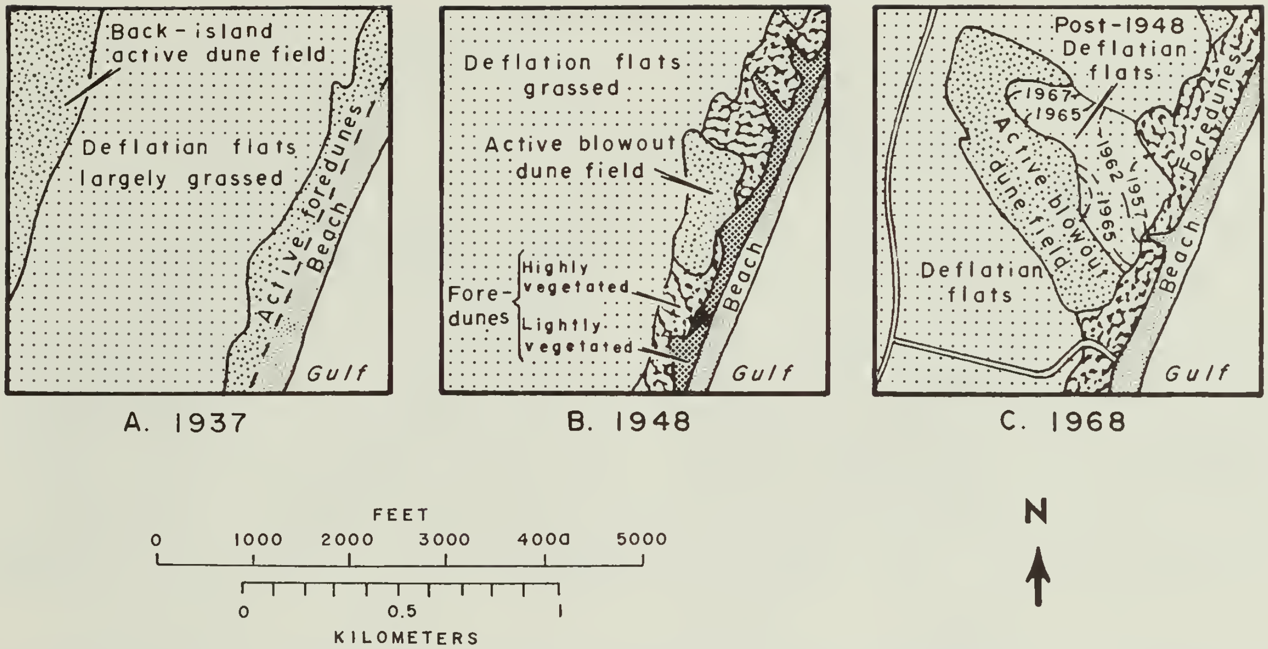


Fig. 11. – Development of a typical blowout dune field, northern Padre Island. The field illustrated is in the vicinity of the beach access road near the north end of Padre Island National Seashore, South Bird Island 7.5-minute quadrangle (Hunter and Dickinson, 1970) and is the locale for STOP 1 of this field trip.

blown across these vegetated areas, and the blowout dune fields have continued to move without further addition of sand except by the engulfment of vegetated dunes in their path. On southern Padre Island, in contrast, the active dunes are periodically supplied with sand washed across the island during hurricanes (Hayes, 1967).

A period of dune activation more widespread than that beginning in 1948 took place in the late 1800's. Although this dune activation was related to several severe droughts, overgrazing was another factor probably responsible for devegetation of the dunes (Price and Gunter, 1943). The vegetated dunes that existed in the central and seaward zones of the island before this period of activation have since moved northwestward across the island to form the present back-island active dune field (figs. 2, 10D, and 12).

The active dune fields contain a variety of dune types, best exemplified in the large back-island dune field. Transverse and barchan dunes less than 10 feet high are readily formed by a few weeks of moderate to strong winds from the southeast. These dunes, typical of summer conditions, are greatly modified by the occasional strong northerly winds of winter. The only dunes that persist throughout the year are large dunes elongated in an east-west direction (fig. 13). These dunes, which are not parallel to either of the two dominant seasonal components of the annual wind distribution, are of the type that has been called "oblique dunes" on the Oregon coast (Cooper, 1958). Although these dunes were earlier interpreted as being longitudinal in the sense of being elongated parallel to the yearly sand transport direction (Hunter and Dickinson, 1970), more comprehensive wind data suggest that they are oriented obliquely to this direction (fig. 10E, F) as well as to the seasonal components. The orientation of these dunes may owe its stability to the fact that it is parallel to one arm of the summer barchan dunes and is transverse to the northerly winter winds (Price, 1958, p. 53-54).

The internal structures of the dunes are occasionally well exposed on broad wind-scoured horizontal surfaces. These exposures are formed by wind scour after the dunes have been thoroughly wetted by heavy rains; similar surfaces are preserved in ancient dune deposits (Stokes, 1968). The internal structure of a barchan dune, as exposed on one of these wind-scoured surfaces, is illustrated in figure 14. The eolian crossbedding exposed on these surfaces dips unimodally to the northwest, approximately in the resultant sand-transport direction calculated from wind data (fig. 10C, F).

Three major kinds and one transitional kind of eolian stratification can be recognized in the dune deposits (Table 2). Each of the major types forms on one of three kinds of depositional surfaces that occur in dune fields: rippled surfaces, smooth leeward-sloping surfaces, and slipfaces marked by sand avalanches (fig. 15). Each of the types can be recognized by the distinctness of the contacts, thickness, regularity, internal grading, packing, and dip angle of the strata (Table 2 and fig. 16). Any of these stratification types can be deformed by the slumping of coherent sand masses down dune slipfaces (fig. 15D); the resultant deformational structures have been described by McKee and others (1971).

Biogenic structures are less common in the active dune deposits than in the other deposits of Padre Island. However, burrowing insects are present in the dune fields.

DEFLATION FLATS (STOP 2)

The low areas left behind the migrating dune fields may be called deflation flats, as they form by deflation of the

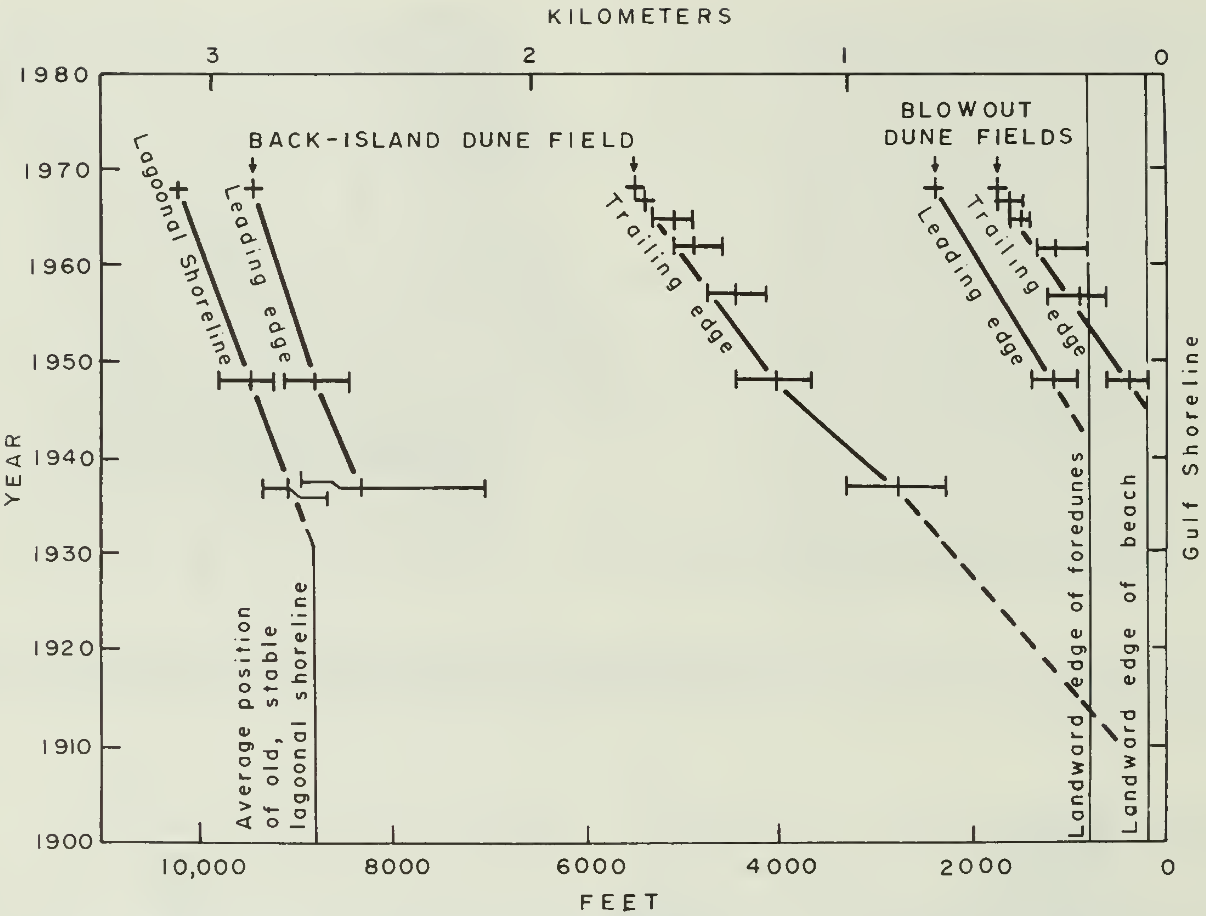


Fig. 12. – Rate of lagoonal shoreline progradation and rates of movement of active dune fields across Padre Island, South Bird Island 7.5-minute quadrangle. The measurements of distance from the Gulf of Mexico shoreline were adjusted so that the 1968 position of a given feature at a given measurement point was the average position of the type of feature measured. The horizontal bars show the range in measurements at different points in the quadrangle.

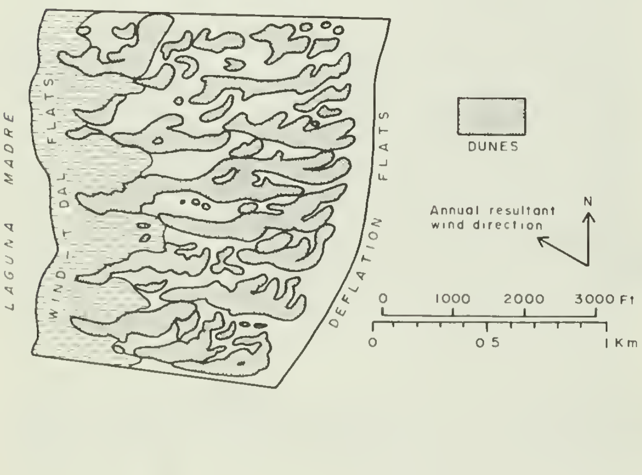


Fig. 13. – Distribution of dunes in a typical area of the back-island active dune field, South Bird Island 7.5-minute quadrangle. Interpreted from aerial photograph taken in September 1968. The large dunes trending east-west are oblique dunes. The unpatterned areas between the dunes are interdune flats.

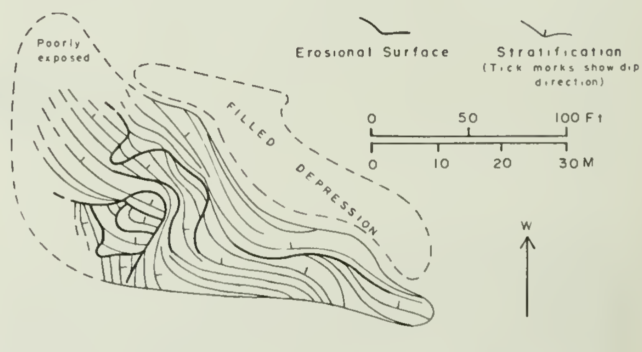


Fig. 14. – Internal structure of a barchan dune, as exposed on a horizontal wind-scoured surface in the back-island active dune field, South Bird Island 7.5-minute quadrangle.

TABLE 2. – Characteristics of structural types of eolian stratification.

Structural type of stratification	Type of depositional surface	Place of origin in dune fields	Dip angle	Thickness of strata; sharpness of contacts	Grain segregation and size grading	Packing	Form of strata
Climbing wind-ripple stratification	Rippled	Windward slopes, low-angle leeward slopes, flats	Low: typ. 0-20° max. 25°	Thin: typ. 2-3 mm; sharp	Distinct, inverse	Close	Tabular
Climbing wind-ripple pseudostratification[1]	Rippled	Leeward slopes	Intermediate: typ. 15-25°	Fairly thin; gradational[2]	Fairly distinct, inverse[2]	Close to intermediate	Tabular[2]
				Thin; gradational[3]	Indistinct, variable[3]		Wavy tabular[3]
Parallel stratification	Smooth	Leeward slopes	Intermediate: typ. 20-30° max. 36°	Thin where well exposed; gradational	Indistinct, variable	Intermediate	Tabular
Sand-flow cross-stratification[4]	Avalanched	Slipfaces	High: typ. 28-34°	Thick: typ. 2-5 cm; sharp	Distinct, inverse[5]	Open	Tongue shaped to roughly tabular

[1] The pseudostratification is accompanied by wavy parallel stratification. The pseudostratification is defined by the lines joining successive positions of ripple crests.

[2] Refers to the pseudostratification component of the structure.

[3] Refers to the wavy parallel stratification component of the structure.

[4] Slumping, another form of avalanching on slipfaces, does not produce a new type of stratification but, rather, deforms the original stratification.

[5] Distinct grain segregation occurs only near the basal contact; the bulk of the cross stratum is nearly structureless. Normal grading may occur near the toe of the cross stratum.

sand making up the dunes. However, they are not perfectly flat but rather are marked by a series of low ridges and troughs formed by dune migration during alternating wet and dry periods, in a manner shown in figure 17. Small dune mounds and larger ridges aligned longitudinally to the direction of sand transport were also left behind the moving dune fields because of stabilization by vegetation.

As the deflation flats are essentially erosional surfaces, the sand underlying these flats is perhaps the oldest sand exposed on northern Padre Island. It differs from the other, younger sands in being slightly coarser, a feature probably indicative of a southern source (Dickinson, 1971). In many parts of the deflation flats, this older sand is probably covered by a thin veneer of more recent eolian sand. Muddy sand rich in algal remains has been deposited in the intermittently flooded depressions.

The sand underlying the deflation flats is nearly structureless, probably because it has been thoroughly mixed by the growth and decay of plant roots and by burrowing animals. Animals that burrow or utilize burrows in the deflation flats include the pocket gophers, ground squirrels, mice, snakes, and a variety of small insects.

WIND-TIDAL FLATS (STOP 2)

The lagoonal margin of Padre Island is marked by flats that are occasionally covered by the waters of Laguna Madre. The variations in water level in Laguna Madre are not primarily due to astronomical tides but rather to wind-set-up tides, in which wind pushes water into, out of, or against one side of the lagoon (Rusnak, 1960; Hayes, 1967). The most drastic flooding of the flats is produced by the storm surges and heavy rains accompanying hurricanes.

The wind-tidal flats of northern Padre Island are underlain largely by sand blown or washed from the back-island dune field. Only the upper couple of feet of sand was deposited on surfaces similar to the present flats.

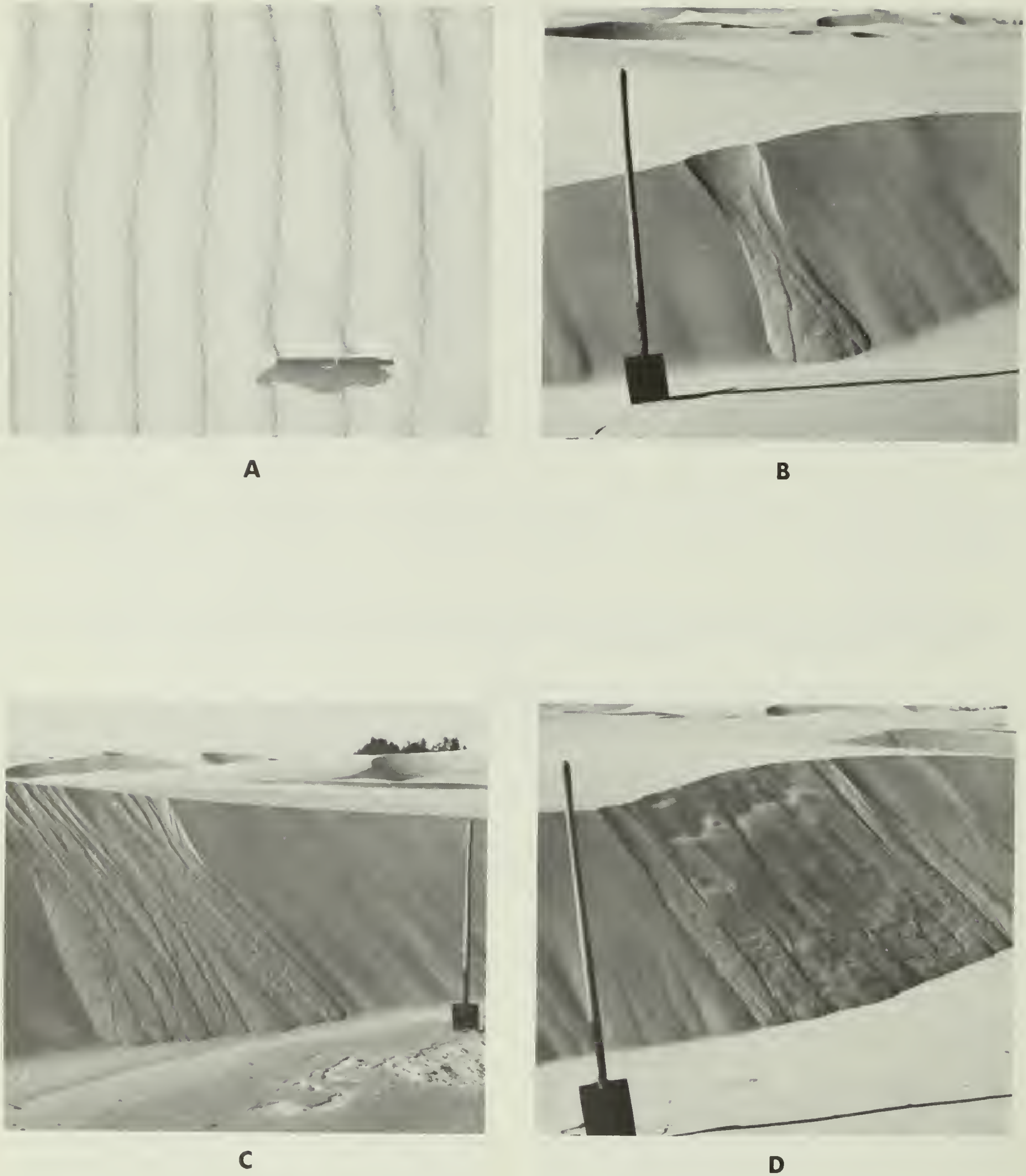
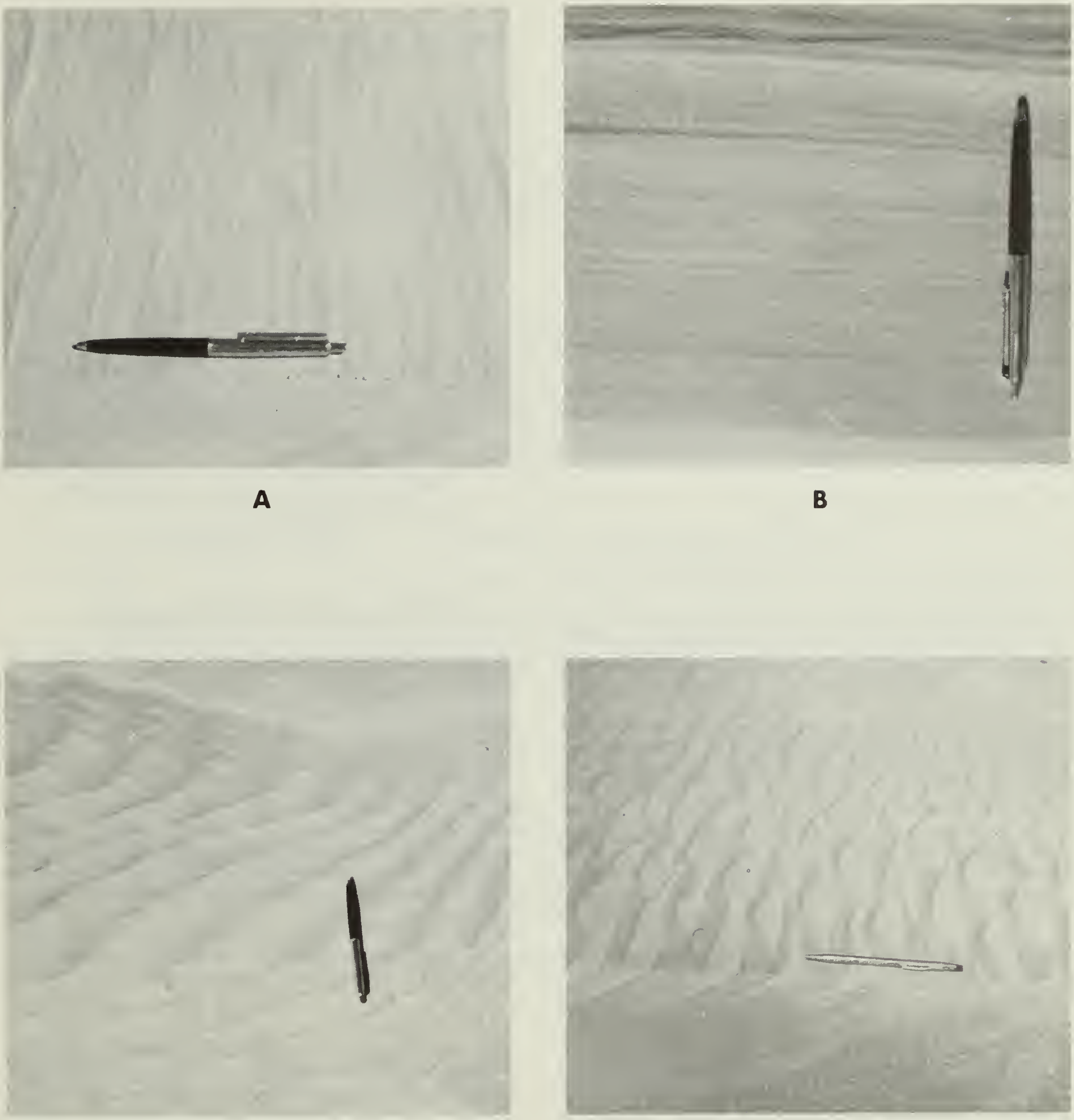


Fig. 15. – Types of depositional surfaces in dune fields. A.– Wind ripples. Although wind ripples in dune fields occur on both windward-facing and leeward-facing slopes, the leeward-facing slopes are much more likely to be depositional surfaces. B.– Slipface marked by a sand flow, a type of avalanche in which the grains move relatively to each other. Note that portions of the slipface are smooth; here, sand has fallen onto the surface but has not undergone further movement by avalanching. C.– Slipface marked by a composite sand flow. On relatively high slipfaces such as this, an initial sand flow triggers other flows along its margins, leading to a composite flow. D.– Slipface marked by slumps with subsidiary sand flows. A slump is a type of avalanche in which a sediment mass moves as a unit along a shear surface at the base of the mass.



A B C D

Fig. 16. – Structural types of stratification in dune sands. A.– Stratification formed by climbing wind ripples, exposed on a horizontal wind-scoured surface and on a vertical trench face. Each layer was produced by a single wind ripple that climbed at a low angle, or migrated across a surface on which relatively slow deposition was taking place. Note that ripple foresets within the layers are not visible. B.– Parallel stratification exposed on a horizontal wind-scoured surface; the stratification dips toward the top of the photo. This type of stratification is formed by sand falling on a smooth surface, such as occurs in the wind shadow leeward of a dune crest. C.– A type of stratification transitional between the types shown in A and B, exposed on a horizontal wind-scoured surface; the stratification dips toward the top of the photo. This type of stratification is formed when wind ripples climb at a high angle, or migrate across a surface on which relatively rapid deposition is taking place. Two components coexist in this structure: (1) pseudo-stratification defined by successive positions of individual wind ripples, and (2) wavy parallel stratification defining successive positions of the rippled depositional surface. D.– Sand-flow cross-stratification, exposed on a horizontal wind-scoured surface and in a vertical trench face. The light-colored lenses on the horizontal surface are cross sections through the toes of tongue shaped sand flows such as those shown in figure 15B.

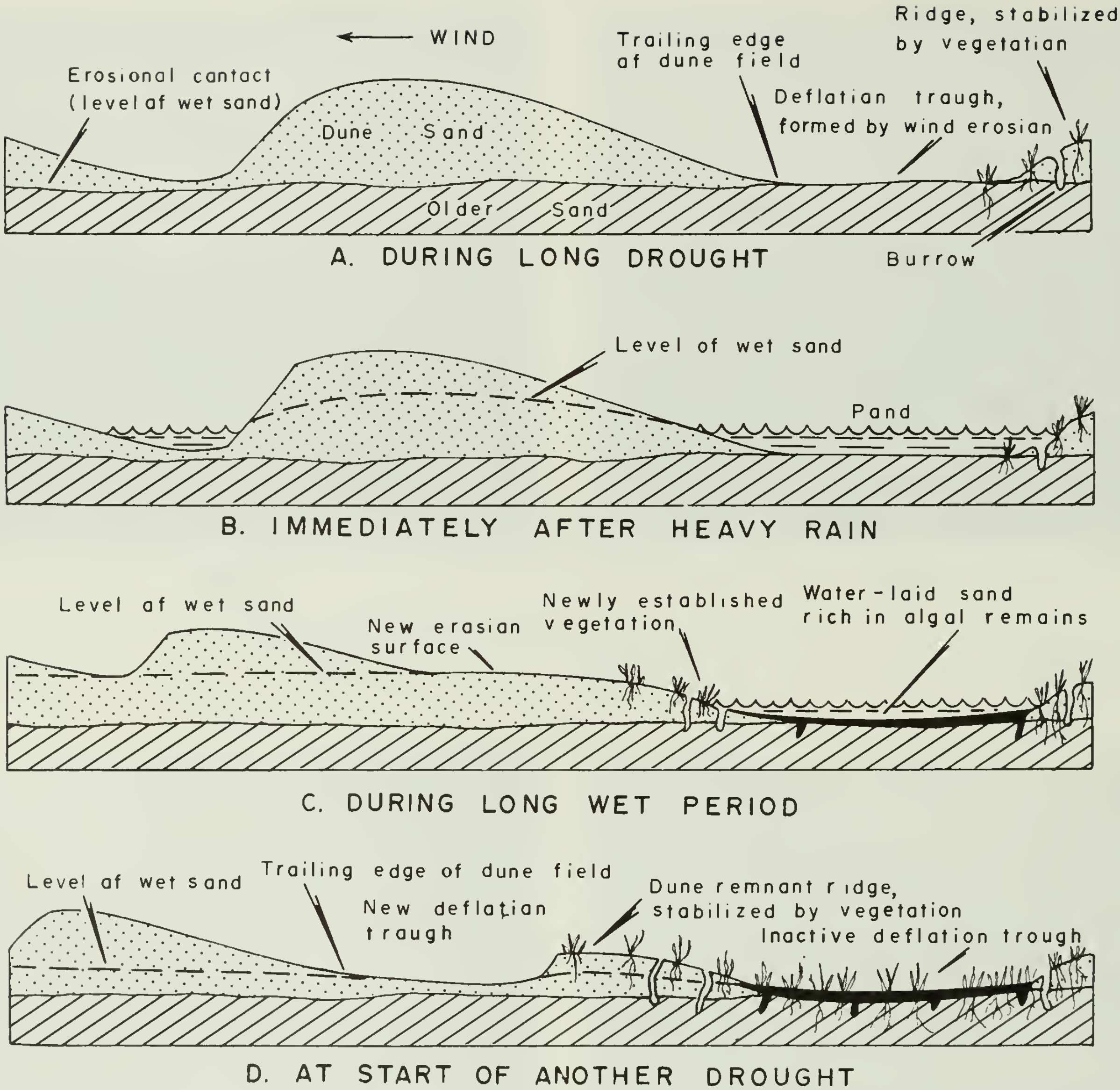


Fig. 17. – Schematic cross sections across the trailing edge of the back-island active dune field, illustrating the manner in which low ridges and troughs are formed in the deflation flats. The troughs are eroded down to the level of wet sand during droughts, while the ridges are stabilized by vegetation that invades the edge of the dune field during wet periods.

Below that and down to a depth of about 5 feet, the sand was deposited subaqueously on a relatively steep slope that formed the eastern edge of Laguna Madre and gradually prograded westward into the lagoon. Below a depth of about 5 feet is a mud bed which probably formed the floor of Laguna Madre before the back-island dune field began encroaching on the lagoon. Thin mud layers rich in algal remains occur throughout the sand section; one such layer was deposited as an aftermath of Hurricane Beulah in 1967, when the flats were extensively flooded by very turbid water.

LAGUNA MADRE

Like the Gulf shoreface of the island, the sediments of Laguna Madre will not be accessible to participants of this field trip, but a short description is included because of the intimate association of the island and lagoon. Laguna Madre is a shallow water body whose northern part has a maximum water dpeth of 8 feet. The thickness of Holocene deposits in northern Laguna Madre is about 20 feet. If it is assumed that deposition in the lagoon began about 5,000 years ago, the rate of vertical infilling has been about 0.4 foot per 100 years (Rusnak, 1960). Lateral infilling by dune migration from Padre Island has been much more rapid, at a rate of about 35 feet per year since 1948 (fig. 12).

The bottom sediment of northern Laguna Madre consists of muddy shelly sand which contains Foraminifera, plant fragments, coated grains, and polychaete worm tubes. The mean grain size of the sand fraction averages 2.6 ϕ, only slightly finer than the 2.5 ϕ average of Padre Island sands. Among dead whole shells in the bottom sediment, *Anomalocardia cuneimeris* and *Mulinia lateralis* are

dominant, being present in all samples and averaging 89 and 6 percent, respectively. Other species present in amounts greater than 1 percent in one or more samples are the pelecypods *Tellina tampaensis*, *Macoma tenta*, and *Laevicardium mortoni*, and the gastropods *Cerithium variabile*, *Retusa canaliculata*, *Turbonilla interupta*, *Acteon punctostriata*, and *Crepidula fornicata*.

Despite the digging of the intracoastal waterway, which disrupted the depositional patterns in Laguna Madre in 1949, certain patterns of sedimentation are still visible or have become visible again (fig. 18). Sediments are coarser, and a lower diversity of invertebrate fauna is present on the mainland side of the lagoon. The clay and silt fraction is greater on the island side, and the shell fraction (coarser sediment) is greater on the landward side. These depositional patterns are apparently related to wind-produced energy levels, which are greater on the mainland side because the predominant wind direction is from the southeast in Laguna Madre, and the waves on the mainland side of the lagoon have greater fetch.

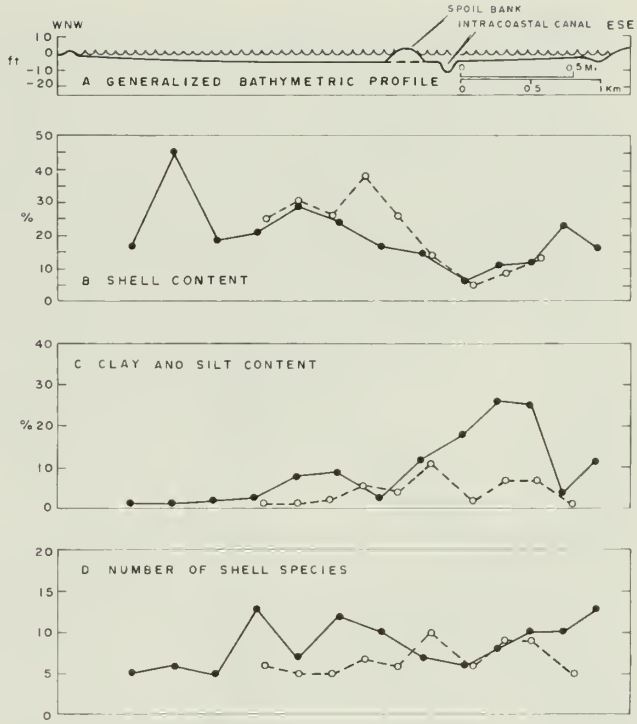


Fig. 18. – Variation in sediment character across Laguna Madre. The two lines of samples are in the South Bird Island 7.5-minute quadrangle. Both lines extend from mainland shore to island shore; they are superimposed in such a way that the position of the intracoastal canal on each sample line is directly below the position shown on the generalized bathymetric profile.

LONGSHORE VARIATIONS IN BEACH SEDIMENT AND ORIGIN OF THE SHELL BEACHES (STOPS 3, 4, AND 5)

By Richard L. Watson

Central Padre Island, Texas, is the site of beaches that are composed of as much as 80 percent shells and shell fragments. This zone of shell accumulation is in the center of a major terrigenous province, and it coincides with the location of a postulated convergence of nearshore Gulf of Mexico currents and littoral drift.

Numerous outcrops of shell conglomerate occur along the mainland shore of Laguna Madre adjacent to central Padre Island. These rocks apparently are lithified equivalents of the shell-rich beach sediments of Padre Island and are probably a part of the ancient Ingleside Barrier Complex (fig. 1). These ancient shell beaches probably formed by the same mechanism as the modern shell beaches of Padre Island, and a study of the origin of the modern shell beaches may provide the means for interpreting the current patterns that produced the ancient shell beaches.

The material in this section is largely reprinted from a paper published by Watson in 1971.

TERRIGENOUS SEDIMENTS

The source rivers for many of the barrier-island sands of the Texas coast have been identified by analysis of the heavy minerals of the beach sands (Bullard, 1942). Within the area of shell beaches on central Padre Island is a transition from a southern sedimentologic province, having sands characterized by their content of basaltic hornblende and pyroxene from the Rio Grande, to a northern sedimentologic province, having sands characterized by the more durable heavy minerals, such as garnet, staurolite, rutile, zircon, and tourmaline (fig. 19). The heavy minerals of the northern province are indicative of source rivers such as the Nueces, Guadalupe, and San Antonio, which drain areas of sedimentary rocks that contain only relatively stable heavy minerals. The existence of a transition zone on central Padre Island between sediments derived from the Rio Grande and sediments derived from rivers farther north along the coast is supported by the finding of van Andel (1960) and van Andel and Poole (1960), who mapped heavy-mineral distributions in the bays, beaches, and continental shelf of the Gulf of Mexico (fig. 20 and Table 3). Van Andel further suggested that most of the distribution of Rio Grande sediments north of the present mouth of the Rio Grande may be explained as the result of the formation of the barrier islands by reworking of Pleistocene deltaic sediments of the nearshore Gulf. He noted, however, that some longshore drift of Rio Grande sediments to the north is indicated by a small northward displacement of the northern limit of the Rio Grande province on Padre Island as compared with the lagoon and with the morphological boundary of the delta. Hayes (1964, 1965) traced a finer grain-size mode from the northern province and a coarser grain-size mode from the southern Rio Grande province to a central transition zone where they mix (fig. 21). These heavy-mineral and grain-size mode transition zones coincide and are within the area of shell beaches on Padre Island (fig. 24).

SHELL SEDIMENTS

Assemblage distribution. – Throughout the study area, large accumulations of shell material are found only on the Gulf of Mexico beaches; only very small shell concentrations occur in the foredunes, active dune fields, barrier island flats, and wind-tidal flats. Two distinct shell assemblages occur along the beaches of Padre Island. The southern sedimentologic province (from 38 miles north of Mansfield Pass southward to the Rio Grande) is

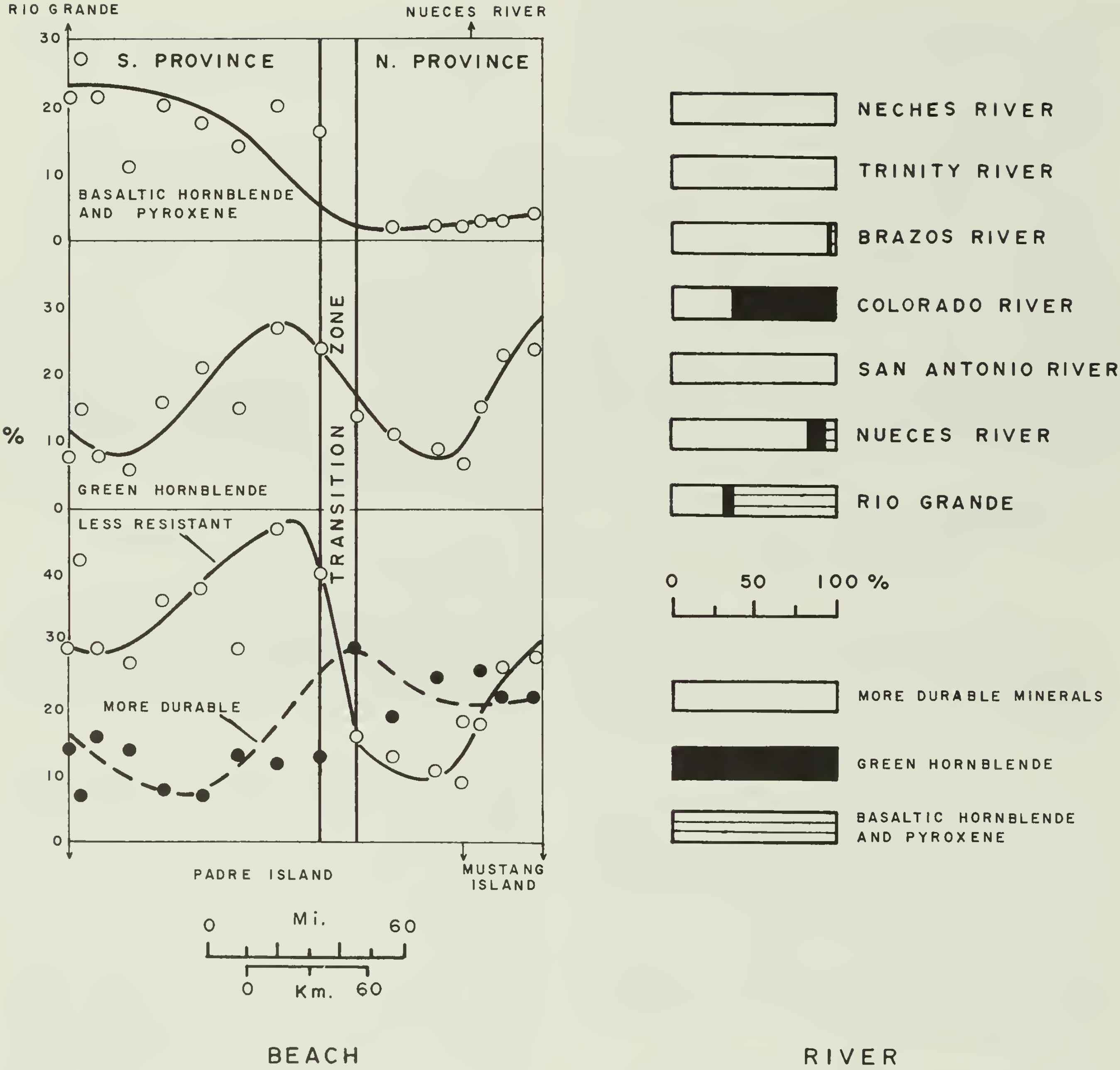


Fig. 19—Heavy-mineral distribution in beach and river sands, Texas Gulf coast. Modified after Bullard (1942).

characterized by *Eontia ponderosa* Say, *Mercenaria campechiensis* Gmelin, and *Echinochama arcinella* Linne (figs. 22 and 23). In the northern sedimentologic province, the shells are almost entirely *Donax* sp. Say. The transition zone between the northern and southern sedimentologic provinces is characterized by a lower total shell content and a somewhat greater accumulation of *Anadara braziliana* Lamarck, *A. ovalis* Bruguiere, and *A. baughmani* Hertlein, three species which are common to both provinces.

With the exception of *Donax*, the source of each species is uncertain. During the course of the study, *Donax* was observed to live in the edge of the surf in dense colonies all along Mustang Island south to the southernmost limit of the northern sedimentologic province on Padre Island. As can be seen from the shell percent curve (fig. 23), there is no accumulation of *Donax* or any other species north of 55 miles north of Mansfield Pass. Thus, *Donax* appears to live and die in the surf zone throughout the northern sedimentologic province and is carried south to accumulate near the southern end of the northern province. The *Anadara* probably live throughout the study area in the shallow shelf zone, either within the surf or slightly beyond it. The *Mercenaria*, *Eontia*, and *Echinochama* common to the southern province probably represent an older reworked shell assemblage. No unabraded valves were found. The *Mercenaria* are highly discolored and have been dated, the 10 dates ranging from 1240 to 7180 years old (personal

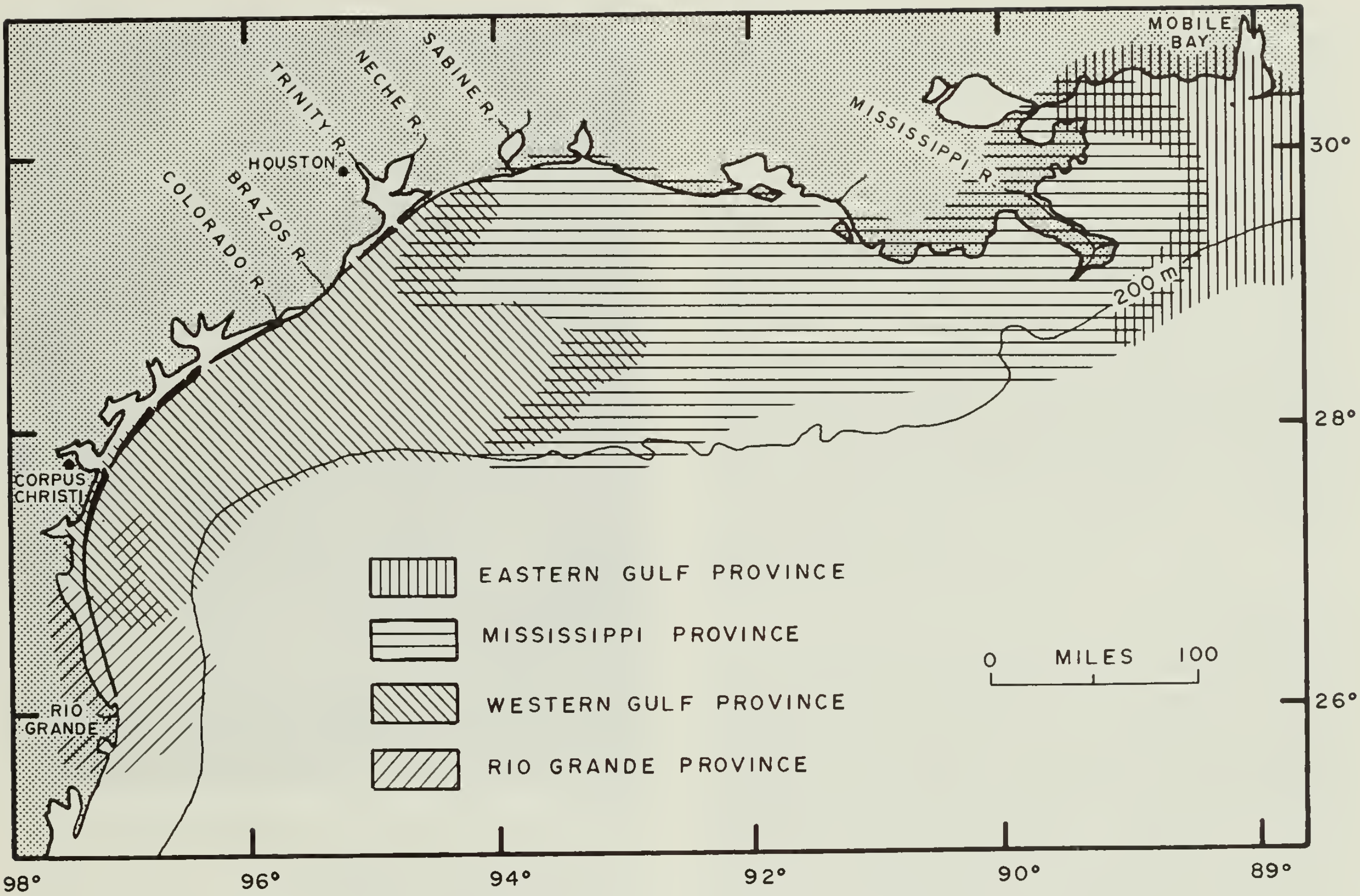


Fig. 20. – Heavy-mineral distribution, northwest Gulf of Mexico. Simplified after van Andel (1960).

TABLE 3. - Average heavy-mineral composition of associations characterizing northern Gulf of Mexico provinces

[In percent of total nonopaque fraction. Modified from van Andel (1960).]

Province	Source	Hornblende[1]	Tourmaline	Epidote	Zircon	Garnet	Staurolite	Kyanite	Pyroxenes	Basaltic hornblende	Others	No. of samples
Eastern Gulf	Cretaceous, Tertiary, Quaternary, S. Appalachians	13	12	16	12	2	16	16	3		10	31
Mississippi	Mississippi River	40	2	16	2	9			25	2	3	116
Western Gulf	Complex	58	5	17	4	7	1	1	3		3	127
Rio Grande	Rio Grande	23	3	15	6	10	1	2	24	7	9	41

[1]Not including basaltic hornblende.

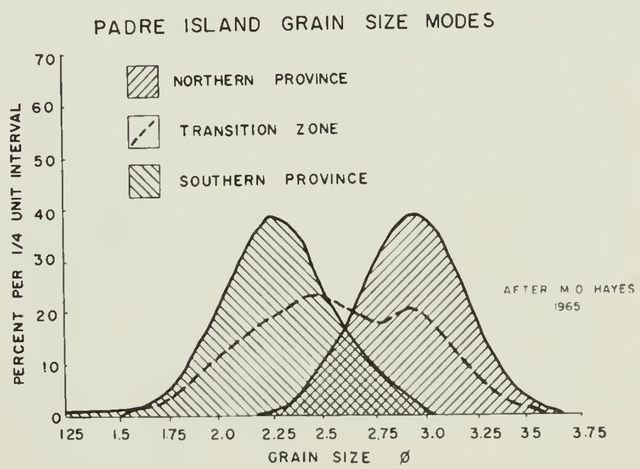


Fig. 21. – Frequency distribution curves for three Padre Island dune samples (Hayes, 1965, p. 234). Note near normality of "coarse" south end-member and "fine" north end-member, as opposed to the strong bimodality of the central sample.

communication, E. William Behrens, 1971). The *Echinochama* usually live attached to a hard substrate in youth. Adjacent to the southern province offshore are numerous submerged ridges of sandstone. This is a likely source for the *Echinochama*, or they may be reworked from an unknown source.

Even though the source for the southern assemblage is unknown, the distribution of abraded valves of the species present indicates their alongshore direction of transport. South of a point about 25 miles north of Mansfield Pass, whole but abraded valves of *Mercenaria* are common. The percentage of whole valves decreases to the north. Still farther north, whole *Mercenaria* valves are absent, and only abraded plates remain. Finally, as one passes through the transition zone into the northern province, it becomes impossible to find even small fragments of *Mercenaria*. Thus, distribution and changing character of the assemblages suggest that the *Mercenaria, Eontia,* and *Echinochama* assemblage has a source to the south and is being transported north, the *Donax* assemblage has a source to the north and is being transported south, and the *Anadara* group has a wide source and is being introduced into both the northern and southern provinces.

Shell concentration alongshore. – Approaching the area from the north, the shell content abruptly increases from less than 1 percent to nearly 50 percent in a distance of only 4 miles (fig. 23). The northernmost high shell concentration between 55 and 45 miles north of Mansfield Pass is composed of the shell assemblage of the northern sedimentologic province; this section of beach is commonly known as "Little Shell." From 40 miles north of Mansfield Pass to about 30 miles north of Mansfield Pass, there is another high in shell content corresponding to an accumulation of the species common to the southern province; this section of beach is commonly known as "Big Shell." Except for a low concentration at Mansfield Pass, the shell content fluctuates around 20 percent in the remainder of the area to the south. Thus, within the area of shell

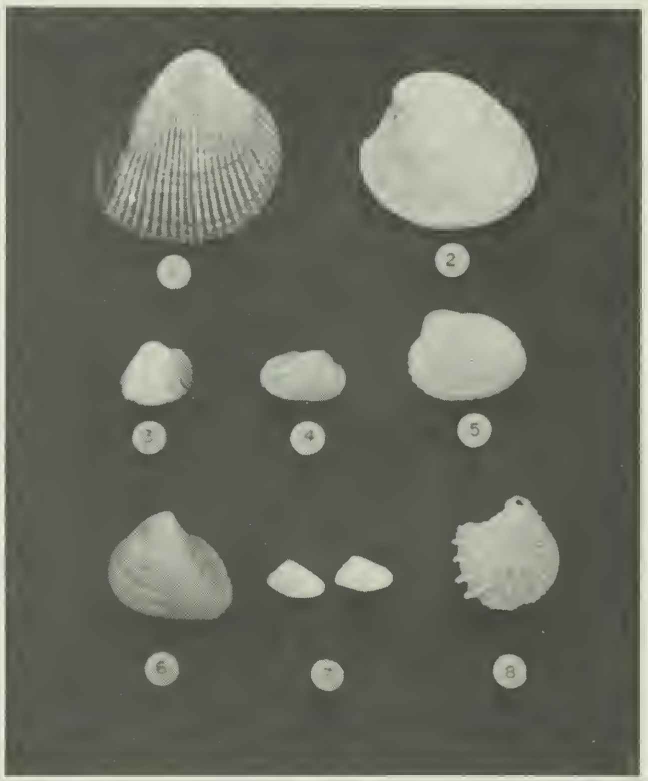


Fig. 22. – Abundant pelecypods of Padre Island shell beaches.
1. *Dinocardium robustum* **Solander**
2. *Mercenaria campechiensis* **Gmelin**
3. *Anadara braziliana* **Lamarck**
4. *Anadara baughmani* **Hertlein**
5. *Anadara ovalis* **Bruguiere**
6. *Eontia ponderosa* **Say**
7. *Donax* **sp.**
8. *Echinochama arcinella* **Linne**

The diameter of the white number circles is 1.5 cm.

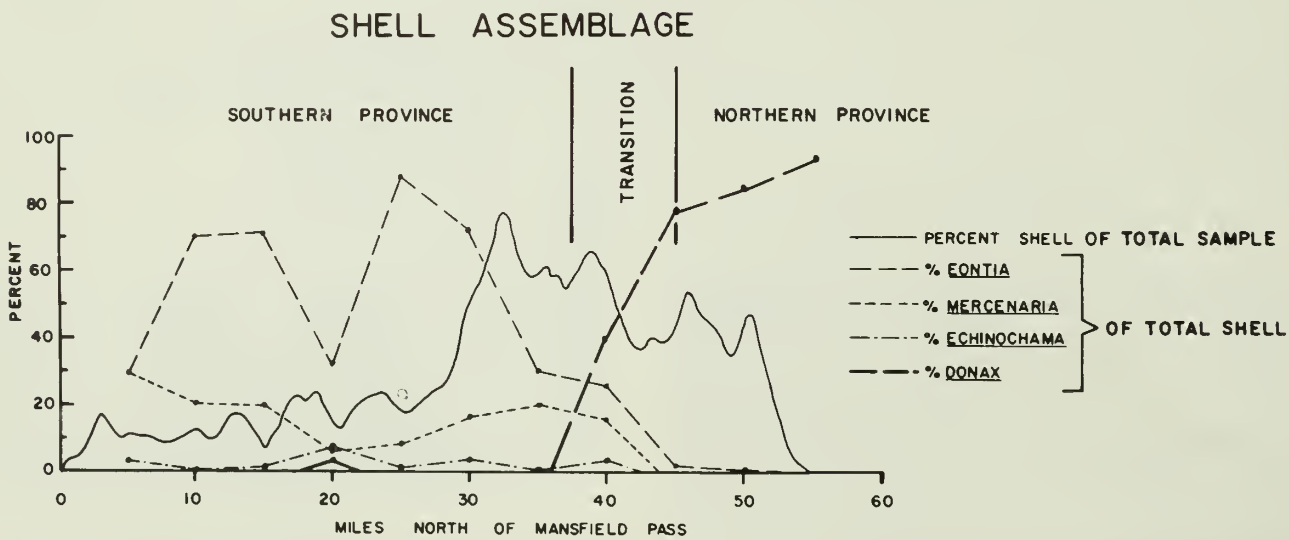


Fig. 23. – Shell assemblage distribution. Note that the abundance of the species of the southern province decline in the transition zone and are virtually nonexistent in the northern province. *Donax* makes up most of the northern province but declines in abundance in the transition zone and is not found in the southern province, except in one small colony about 20 miles north of Mansfield Pass. The transition zone based on shell assemblage corresponds with a low in shell content. The shell percent curve is the second derivative of a three point moving average.

beaches, there are three major zones based on shell concentration. These correspond with the three shell assemblage zones.

Local correlation with dune topography. – A study of the topographic maps of Padre Island shows a central belt of high foredunes, which roughly corresponds with the zone of maximum shell content. A careful study of the location of the many local maxima on the shell-content graph (fig. 23) and the location of high and continuous parts of the foredune ridge shows a nearly perfect correlation. That is, where the dunes are high and continuous, there is a local maximum in shell content. Where the dunes are low or where there is a hurricane channel or washover fan there is a local minimum of shell content. The high continuous dunes serve as an impenetrable wall to all but the most powerful storms. Coarse shell deposited on the beach in the vicinity of these dunes must remain there because no physical process can remove it. The wind is competent to remove only the finer material which is predominantly terrigenous sand. In contrast, where this wall is breached by hurricane washovers, the shell is periodically removed at least in part by being washed into the interior of the barrier island. This process is self-reinforcing. Where the dunes are the highest and most continuous and the shell content is high, the backshore elevation is usually very high because the coarser grained shell material builds steeper beaches than the fine terrigenous sand. Because of the high backshore produced by the high dunes, only the largest storms with very high tides can reach the foot of the dunes. Thus protected, the dunes can build still higher and become stronger and better able to resist future wave attack. It should not be inferred that the regional maximum in shell content is a result of the presence of high and continuous dunes. Elsewhere on Mustang and Padre Islands, there are similar areas of well-developed foredunes adjacent to beaches with less than 1 percent shell material. Positive correlation between shell content and foredune development occurs only in the littoral drift convergence.

Transition zones. – A map of the postulated longshore drift convergence area (fig. 24) shows the transition zones determined by Bullard (1942) and by van Andel and Poole (1960) for heavy minerals and by Hayes (1964, 1965) for grain-size modes. The transition zone based on shell assemblage and shell content falls within the limits of Bullard's samples and only a short distance north of the transition zone as defined by Hayes. The shell data may be somewhat more accurate, because of the close sample spacing. All these data support the suggestion that there is a sedimentologic transition zone produced by longshore drift convergence in the central part of Padre Island. The shell assemblage and shell-content data limit the width of the transition zone to about 8 miles.

Shell concentration normal to shore. – Shell content was determined on 10 traverses across the beach normal to the shoreline. The shell distribution seaward of the storm berm is irregular. Nearly pure shell deposits occur in parts of the active berm crest and in the horns of active cusps. The storm berm contains either the maximum or nearly the maximum shell content in a profile across the beach. The shell content then diminishes toward the foredunes (fig. 25). The foredunes, vegetated flats, and wind-tidal flats further inland are composed nearly completely of terrigenous materials.

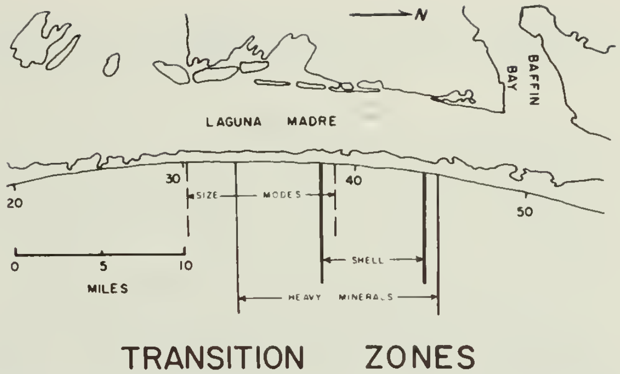


Fig. 24. – Transition zones shown by grain size, heavy minerals, and shell content. The transition zones for heavy minerals (Bullard, 1942; van Andel, 1960), for grain-size modes (Hayes, 1965), and for shell percent and assemblage distribution (this study) are shown. The numbers along the shore of Padre Island indicate the distance in miles north of Mansfield Pass.

SEDIMENTARY PROCESSES

A high shell concentration such as is found on Padre Island can be the result of three possible conditions: an extremely high shell supply, and extremely low terrigenous sediment supply, or some sorting phenomenon leading to a shell concentration. There is no evidence of an extreme abundance of living communities. In fact, the greatest abundance of living *Donax*, the main contributor to the northern assemblage, is on Mustang Island and northern Padre Island where the shell content of the beaches is less than 1 percent (fig. 23). Terrigenous sediment is not lacking, as central Padre Island is one of the widest barrier islands of the coast, Laguna Madre inland from central Padre Island is completely filled with sand blown from Padre Island, and old shell beaches exposed in depressions behind the frontal dunes of the foredune ridge indicate that the island has accreted seaward during its history. Therefore, the shell concentration on Padre Island must be a sorting phenomenon.

Longshore drift. – Evidence is abundant for a convergence of littoral drift on central Padre Island in addition to the sedimentologic evidence of the three transition zones described above. According to Lohse (1955), the currents of the south Texas coast move northward to a meeting place about lat. 27° N. Curray (1960) correctly observed that the convergence is not actually stationary, but migrates north and south along the coast in response to seasonal changes in wind direction. Drift-bottle data for the Texas and Louisiana coasts indicate that most of the currents are directly wind driven (Kimsey and Temple, 1963, 1964; Watson and Behrens, 1970). Further data, gathered in 1970 using releases of ballasted drift bottles and seabed drifters, provide additional evidence that nearshore currents frequently converge in the vicinity of Padre Island (Hunter, Garrison, and Hill, unpub. data). These data indicate that the nearshore currents tend to be driven in the direction of the seasonal winds, that is, northward during the summer and southward during the winter. However, southward currents tend to persist through the spring and early summer months long after the southerly winds have become established, thereby tending to maintain a convergence of nearshore currents in the vicinity of central Padre Island.

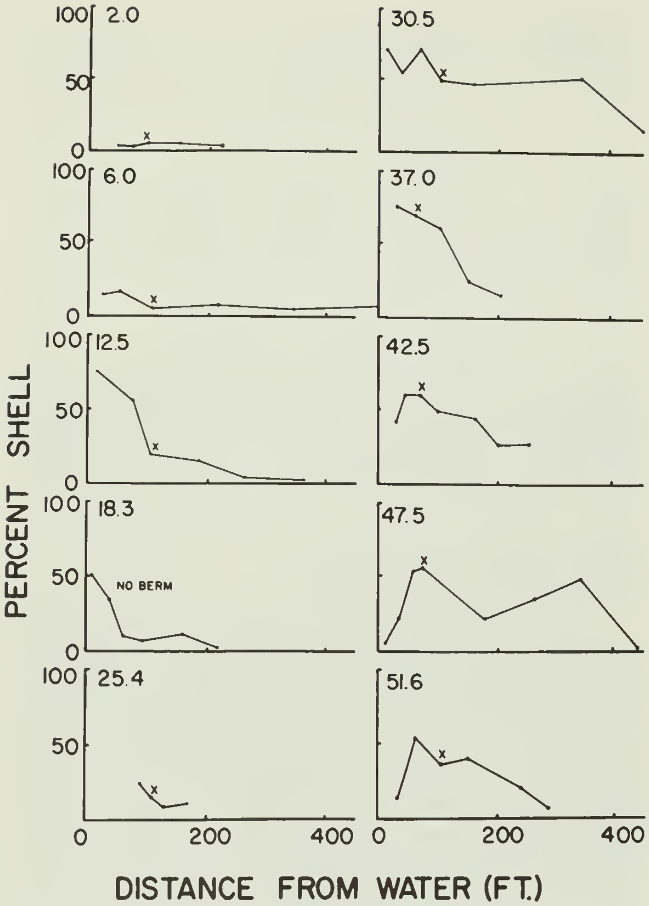


Fig. 25. – Shell distribution along traverses perpendicular to the shoreline. The shell concentration versus distance landward from the edge of the water is plotted for a series of 10 traverses across the width of the beach throughout the study area. The number in the upper left-hand corner of each graph is the distance in miles that the traverse is north of Mansfield Pass. The small x by the trace of the graph denotes the approximate location of the crest of the storm berm on each traverse. The shell content is irregular seaward of the storm berm and decreases landward from it.

Monthly wind data collected by the U.S. Weather Bureau station at Corpus Christi for the years 1951-1960 give the average velocity and duration for each 16 compass directions. Monthly, annual, and 10-year vector resultants were determined for both velocity and velocity squared for the Corpus Christi data (fig. 26). The annual resultant for the 10-year period ranges between 111° and 135° with a 10-year resultant of 121°. The resultant for V^2 ranges between 110° and 135° with a 10-year resultant of 123°. Data for 1965 and and 1966 fall within the limits of the 10-year data described above. In addition, Price (1933) presented a vector diagram of the wind direction, duration, and square of the velocity for the period 1923-1930. The annual vector sum derived from this diagram is 120°. Thus, several different computations of the vector sum of the winds for Corpus Christi all provide an annual vector sum of about 120°.

A wind blowing into a concave shoreline such as the south Texas coast will produce waves, which in turn will produce a convergence of longshore drift at the point where the wind direction is normal to the shoreline (fig. 27). The direction of the net annual resultant wind for Corpus Christi is about 120°, which is normal to the shoreline in the vicinity of Aransas Pass. This suggests a net convergence of longshore drift in that area. Although at any one time sediment is either moving north or south through the entire area, the long-term effect is the net convergence of longshore drift.

The convergence location determined by wind analysis at a single point is only approximate. Sedimentation at inlets can also be used to estimate the location of the long-term convergence. The south jetty of Mansfield Pass has accumulated a huge fillet of sand, whereas the beach just north of the north jetty is eroding. This indicates a strong net littoral drift to the north at Mansfield Pass. Aransas Pass had a history of migration to the south before stabilization (U.S. Army Corps of Engineers, undated). Spit development at Corpus Christi Pass during its closure following Hurricane Beulah in 1967 demonstrates that the net drift at that point is southward. Therefore, if the net littoral drift is southward at Corpus Christi Pass and northward at Mansfield Pass, there must be a net convergence of littoral drift between these two points. This convergence provides the mechanism to supply large amounts of shell material to central Padre Island. It will, however, provide a very large terrigenous supply as well. In fact, it should result in the greatest total longshore sediment supply of any beach anywhere along the coast, as sediment is being brought in from the south and from the

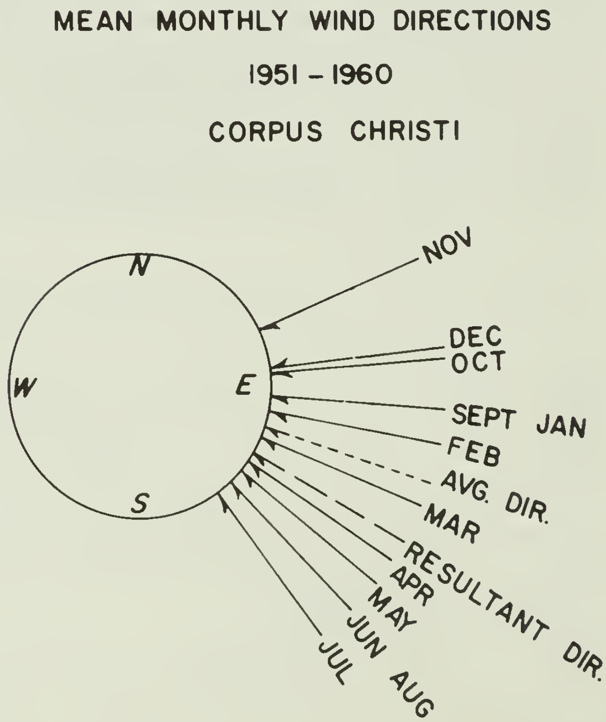


Fig. 26. – Mean monthly wind directions for Corpus Christi 1951-1960. Directions shown represent the average of the monthly vector resultants determined for 10 years of wind data collected at Corpus Christi. The RESULTANT DIR. shown is the vector resultant for the entire 10-year period. The AVG. DIR. is the average of all of the monthly vector resultant directions for the 10 year period. The resultant direction and the average direction separate the winter regime of northers from the summer regime of strong southerlies if March is taken to be a transitional month.

north, and once into the convergence area, littoral drift can no longer carry it away.

Wind deflation. – Within the convergence area, shell is concentrated on the beach by wind deflation of finer grains. The much finer terrigenous sand can be blown inland to form the foredunes, vegetated flats, and the wind-tidal-flat infill of Laguna Madre. Some of the sand may also eventually contribute to the aeolian sand plain on the mainland (fig. 1). As the coarse shell material cannot blow inland and cannot be removed by littoral drift, it concentrates on the beaches of the convergence area. Only small amounts are washed inland on hurricane washover fans where the foredune ridge is poorly developed. Thus, the combination of a convergence of littoral drift and subsequent wind deflation of the finer terrigenous sand results in a huge accumulation of shell material in the center of an abundant supply of terrigenous sediment. Abundance of organisms or lack of terrigenous sediments is not necessary to provide this carbonate concentration.

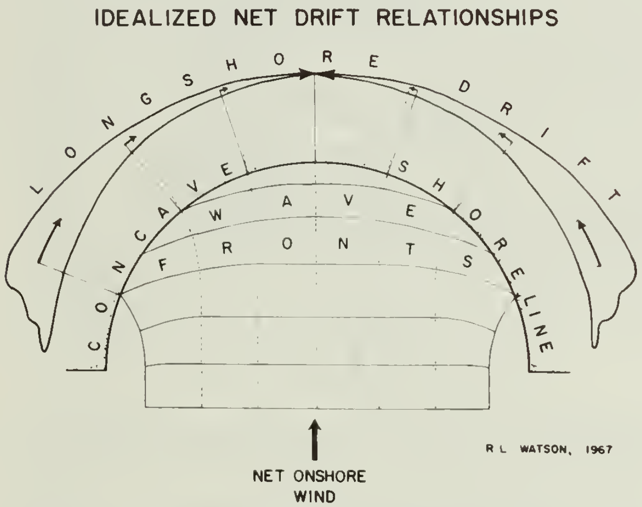


Fig. 27. – Idealized net drift relationships An onshore wind blowing onto a concave shoreline will produce wave fronts normal to the wind direction. These wave fronts move shoreward and are incompletely refracted. As they break, the waves generate a longshore current because of their oblique approach to the shoreline. This current is strongest at the greatest distance from the central point where the waves approach the shoreline at the greatest angle. The current decreases in magnitude toward the center where it diminishes to zero because the waves approach parallel with the shoreline at the point where the wind direction is normal to the shoreline and no current is generated.

PALEOENVIRONMENTAL INTERPRETATIONS

The results of this study of recent sediments can be directly applied to the explanation of some other recent and some Pleistocene sediments in the same area. The old shell beach sediments behind the frontal dunes of the foredune ridge on central Padre Island must surely represent a shell beach directly analogous to the present one. The shell-rich rock outcropping along the west shore of Laguna Madre is probably a Gulf beach of the Pleistocene(?) Ingleside Barrier Complex. Cursory field examination demonstrates that it has approximately the same assemblage composition as the modern shell beaches and has both a northern and southern assemblage province with the transition zone in approximately the same location as on the modern beaches. Therefore, the general configuration, wind circulation, and thus the littoral drift patterns were probably very similar to those of the present on this ancient Gulf of Mexico beach.

SUMMARY

1. A littoral drift convergence on central Padre Island causes shell and sand from the entire coast to accumulate in the convergence area.

2. Shell is concentrated on the beach by aeolian deflation of finer grained terrigenous sand.

3. The excess sand is blown inland to contribute to the extensive infilling of Laguna Madre by wind-tidal flats, and perhaps ultimately to contribute to the aeolian sand plain of the mainland.

4. The great similarity of the Pleistocene shell beaches of the Ingleside Barrier Complex suggests that the general coastline configuration and wind patterns were similar to modern wind patterns at the time of their formation.

5. Large carbonate accumulations can occur as a result of a sorting process in an area of great terrigenous sediment supply.

SHORT SUMMARY OF FIELD TRIP STOPS 3, 4, and 5

STOP 3. Northern sedimentologic province. – This stop is in the northern sedimentologic province, which is characterized by terrigenous sediments supplied from rivers to the north and from relict Pleistocene sediments derived from these rivers and their deltaic deposits. The more durable heavy minerals, such as garnet, staurolite, rutile, zircon, and tourmaline, are common. Green hornblende from the Colorado River is also present (Bullard, 1942). The terrigenous sediments are characterized by the relatively fine size mode of northern Padre Island (fig. 21). The shell assemblage here is dominated by *Donax* sp. (fig. 22). Living *Donax* are sometimes found along these beaches and are living in large colonies along northern Padre Island and Mustang Island. The *Donax* spend their entire life cycle in the shallow surf zone. They move onshore and offshore from the swash zone to water a few feet deep with the changing seasons. After they die, their shells are carried southward by the net southward littoral drift along northern Padre Island to this area in the northern sedimentologic province where they accumulate by aeolian deflation of the finer grained terrigenous sediments, which blow inland to the interior of the island and ultimately contribute to the foredunes, vegetated flats, and the wind-tidal flats that are slowly filling Laguna Madre.

Note the complete absence of species or fragments of the shells of species characteristic of the southern sedimentologic province (fig. 22). As this stop is north of the transition zone between northward-moving longshore currents to the south and southward-moving longshore currents here, no sediment from the southern sedimentologic province can be transported this far north. In addition to the *Donax*, there are numerous whole shells and fragments of the *Anadara* sp. assemblage, such as *Anadara baughmani, A. Braziliana*, and *A. ovalis*. These species occur throughout the area and are not limited to a particular province. They are probably living at present in either the surf zone or the shoreface beyond.

Shell content in the northern sedimentologic province ranges from near zero on northern Padre Island and

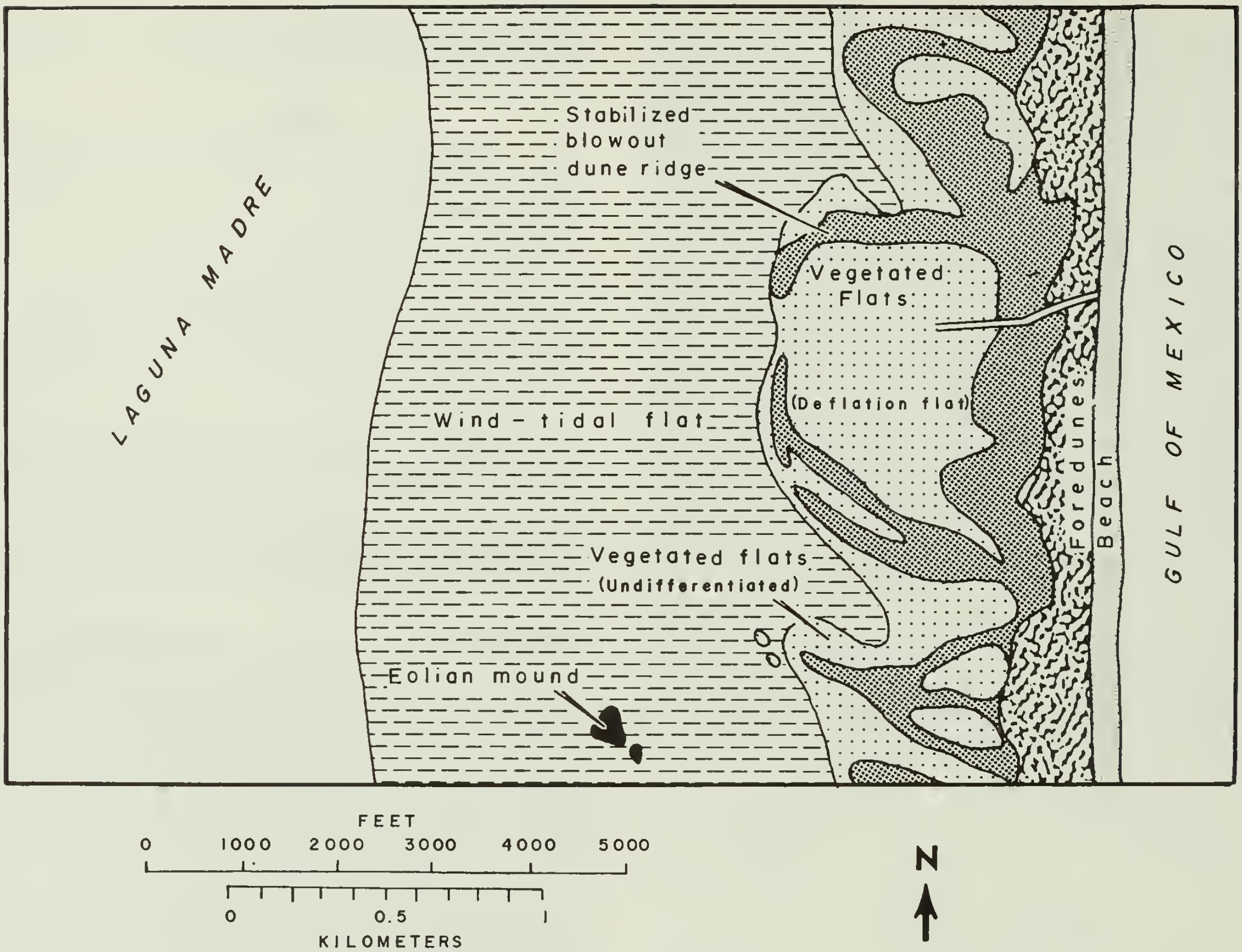


Fig. 28. – Landforms of a typical section of central Padre Island. The mapped area is in the vicinity of the abandoned Dunn Ranch, Potrero Cortado 7.5-minute quadrangle, and is the locale for STOP 6.

Mustang Island in the source area for the *Donax* to a minimum of about 55 percent near the transition zone at the heart of the littoral drift convergence (fig. 23).

STOP 4. Transition zone. – This stop is in the transition zone between the northern and southern sedimentologic provinces. The terrigenous sediments and the shell sediments of both provinces are mixed in this zone which is about 8 miles wide (figs. 23 and 24). Note that, with the exception of a small colony of living *Donax* in the southern sedimentologic province, the species characteristic of the northern province are absent in the southern province, and vice versa. This is also true for the grain-size modes of Hayes (1965) and for the heavy minerals studied by Bullard (1942) and van Andel and Poole (1960). Members of the *Anadara* assemblage (fig. 22) are common.

STOP 5. Southern sedimentologic province. – This province is characterized by terrigenous sediments from the Rio Grande. The modal grain size is coarser than that in the northern sedimentologic province (fig. 21) and the heavy-mineral assemblage is characterized by the presence of basaltic hornblende and pyroxene. The shell assemblage is characterized by *Mercenaria campechiensis, Eontia ponderosa*, and *Echinochama arcinella* (fig. 22). The source for these species is unknown, but most or all of them are probably reworked from older sediments. The *Mercenaria* have been radiocarbon dated; 10 dates range from 1240 to 7180 years old. All are highly worn and discolored, indicating burial and considerable abrasion during transport. The *Echinochama* live attached to a hard substrate in adolescence and may have a source in the numerous ridges of sandstone offshore from southern Padre Island. The source for the *Eontia* is unknown but may be the same as that for the *Mercenaria*.

There is considerable evidence for transport of these sediments to the north. At Mansfield Pass there is a great accumulation of sediment behind the South Jetty, indicating net transport to the north. Also, south of this stop, whole *Mercenaria* are very common. As one moves toward the north and finally enters the transition zone, only abraded plates of *Mercenaria* remain, indicating increasing abrasion and fragmentation to the north and thus transport to the north. There are no *Mercenaria* or fragments north of the transition zone.

TRAVERSE ACROSS CENTRAL PADRE ISLAND (STOPS 5 AND 6)

By Ralph E. Hunter

Central Padre Island may be differentiated from the

northern and southern sections by distinctive features of the beach, foredunes, vegetated back parts of the island, and wind-tidal flats (fig. 28). If defined in the most restrictive sense, on the basis of features in the vegetated part of the island, it extends from 3 to 15 miles south of Yarborough Pass, or from 42 to 30 miles north of Mansfield Pass.

BEACH (STOP 5)

The southern and transitional assemblages of the shell beaches, as defined by Watson (1971 and this guidebook), compose the central section of the island. This section of beach is commonly known as "Big Shell' and is characterized, apart from its shell content, by its high berm and steep foreshore. Its character is more fully described in the section on longshore variation of beach sediment and origin of the shell beaches.

FOREDUNES (STOP 5)

The foredunes of central Padre Island differ from those to north and south by their greater height, more continuous vegetative cover, and greater topographic continuity. An explanation for these differences is offered in the section on longshore variation in beach sediment and origin of the shell beaches.

ACTIVE DUNE FIELDS

Only a few small blowout dune fields are presently active in the central section of Padre Island, and no back-island dune field is present. The vegetative cover of central Padre Island has been more extensive than that of the northern and southern sections since at least 1937, the date of the earliest available aerial photography.

STABILIZED BLOWOUT DUNE FIELDS (STOP 6)

Vegetated sand ridges 5 to 20 feet high are common on central Padre Island. Their origin as blowout dune fields is indicated by their parabolic, convex-downwind form, enclosing low deflation flats between the arms of the parabola (fig. 28). At least some of these sand ridges can be recognized as areas of bare sand on the earliest accurate map of the area, surveyed in the late 1800's. They became stabilized by vegetation sometime before 1937. No other part of the island contains such large areas that have remained unchanged for so long a time.

Eastward, the individual stabilized dune ridges merge into a gently lagoonward-sloping platform on whose eastern edge the foredune ridge is built. The presence of shells on this platform, some of them at elevations of 15 or 20 feet above sea level, suggests that hurricane surges washed over the platform before formation of the present foredune ridge.

VEGETATED BARRIER FLATS (STOP 6)

Low flats vegetated by grass occur both upwind (southeastward) and downwind (northwestward) from the stabilized blowout dune ridges (fig. 28). Those flats upwind from the ridges are deflation flats left behind the formerly moving dunes, whereas those downwind of the ridges and bordering the wind-tidal flats may be either old deflation flats, left behind dunes that have since moved into Laguna Madre and dissipated, or old washover fans. The flats upwind and downwind of the ridges are grouped together here because their underlying deposits, consisting of structureless sand, are probably in lateral continuity beneath the intervening ridges of stabilized dune sand.

WIND-TIDAL FLATS (STOP 6)

The wind-tidal flats along the Laguna Madre margin of central Padre Island are much wider than those in the South Bird Island quadrangle; however, wide wind-tidal flats are not restricted to the central section of the island as defined here but extend some distance north and south (fig. 1). The sand that makes up a large part of the wind-tidal flat deposits must have been washed or blown across the island, but in the central section this must have occurred largely before the foredune ridge and vegetative cover formed to their present extent. In fact, the somewhat lesser extent of wind-tidal flats behind the "Big Shell" beach (in the vicinity of stop 5, fig. 1) than in the areas immediately to the north and south is probably due to the relative protection from hurricane washovers and wind activity furnished by the high foredune ridge and vegetative cover of this section of the island (Hayes, 1967, p. 26-27).

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Dr. Dickinson received a B. A. Degree in 1954, an M. S. Degree in 1959, and a Ph.D. Degree in 1962, all in geology from the University of Minnesota. From 1962 to the present he has been a geologist with the U.S. Geological Survey. He has investigated the Jurassic stratigraphy of northeast Texas and adjacent areas and the oil shales of Colorado. From 1968 to 1970 he studied the Recent sediments of Padre Island; during that time he served as sedimentologist on Leg 10 of the Deep Sea Drilling Project. Currently he is stationed in Denver, Colorado, and is investigating the sedimentary petrology and stratigraphy of uranium-bearing Tertiary deposits in south Texas. He has published numerous papers on geological subjects and is a member of several geological professional societies.

Richard L. Watson received the Arts Bachelor Degree with honors from Lehigh University in 1965. While working toward that degree he began his studies of coastal systems by studying coastal inlets for the New Jersey Bureau of Geology. He received the Master of Arts Degree in geology from the University of Texas in 1968; his Master's thesis research was conducted under the supervision of Dr. E. William Behrens at the University of Texas Marine Science Institute at Port Aransas and involved studies of the beaches of Padre Island, Texas, and the origin of extremely high shell concentrations on those beaches. He has completed research for his Doctoral dissertation, also under the supervision of Dr. Behrens at the University of Texas Marine Science Institute, and expects to receive the Ph.D. Degree in 1973. His Doctoral dissertation research was on the quantitative relationship between the rate of littoral drift, the alongshore component of wave energy flux, and the mean grain diameter of beaches. Mr. Watson is currently carrying out post-Doctoral research on the shoreline and channel changes associated with the opening of the Corpus Christi Water Exchange Pass through Mustang Island, Texas. The project is supported by a contract to the Marine Science Institute from the Coastal Engineering Research Center of the U.S. Army Corps of Engineers.

HISTORY OF PADRE ISLAND

by Betty Callaway
Portland, Texas

The first inhabitants of Padre Island were peoples of Asiatic descent, generally thought to have crossed the Bering Strait some 8,000 years ago. A severe drought presumably destroyed this culture.

The Aransas culture then followed, suddenly disappeared, and was succeeded by a strictly Indian people known as the Rockport culture. The major Indian tribe was Karankawa, although the area was occasionally inhabited by Lipans, Tonkawas and Comanches.

KARANKAWA INDIANS

The Karankawa tribe is thought to have come from the provinces of Northern Mexico, for they spoke a language similar to that of the aborigines of the Tamaulipas region of Mexico. They inhabited Padre Island until the mid-19th century when the surviving 50 to 60 fled to Mexico.

The Kronks were fierce warriers, nomadic fishermen and cannibals. The males were tall, lean and light-skinned in contrast to their women, who were rather squat, fat and coarsely unattractive. Head flattening and tatooing were commonly practiced and they also had a strong aversion to bathing. To protect themselves from mosquitos they applied liberal quantities of fish oil to their bodies.

While the Kronks summers were spent on Padre (about 55 miles north of the southern tip of the island) they migrated to the mainland for the winters. Their favorite crossing point was a small ford at the north end of the island.

Kronk bowmen were the most proficient of all Texas Indians. They had weapons of red cedar and yard long arrows tipped with sharp flint. They certainly did not make an ideal welcoming committee for the first white men to reach the island.

SPANISH EXPLORATION

Alonso de Pineda, who was sent by the governor of Jamaica to explore the entire Gulf Coast, sailed into Corpus Christi Bay in 1519 on the day of the Feast of Corpus Christi. Hence, the name of the bay as it is still known.

Spanish settlements were concentrated near the mouth of the Rio Grande River and those who ventured north in an attempt to inhabit Padre met with tragedy or failure.

Legend has it that the waters of the Gulf and the sands of Padre contain magnificent hidden treasure; the lost cargos of unfortunate Spanish galleons that brought supplies to the early settlements and moved the treasures of Mexico to Spain.

In 1553, twenty of these galleons left Vera Cruz, Mexico, bound for Spain loaded with art objects and other valuables. A powerful gale ripped the fleet–several did manage to navigate back to Vera Cruz–but most were driven ashore on Padre at a place now known as Devil's Elbow.

Some 300 survivors spent six days recuperating from their ordeal. On the seventh day they found themselves surrounded by the terrifying island Indians. The Spaniards who survived the attack retreated south along the island, living on seafood, roots and plants while still pursued by the ferocious warriors. Only one man, Fray Marcos de Mena, reached safety from what is historically called "The Flight of the 300".

There was, however, one other survivor of the shipwrecks–Francisco Vasquez, who remained in the battered hulks of the ships, where he found food, water and safety. He correctly assumed that a salvage fleet would be sent to recover the valuable cargo. Vasquez was rescued a year later and aided in the salvage operation, though how much of that cargo was recovered is not known. Modern day Padre Island adventurers are still hopeful of finding these and other long lost treasures.

No successful attempts at colonization were made on Padre during the 17th or 18th centuries. However, in the early 1800's, Padre Balli received a land grant to the island from King Charles IV, of Spain. The island, named for the priest, became a ranch kingdom for Balli and his nephew, Juan Jose. For three decades the Ballis and their settlement of Santa Cruz prospered, surviving even the pillaging of Jean Lafitte and his pirate bands.

The last of the Ballis left Padre during the 1840's while Texas struggled for its freedom from Mexico and for a brief time the island was unoccupied.

AMERICAN ENTREPRENEURS

During the waning days of the Texas Republic, Colonel H. L. Kinney established a trading post on the southern edge of Corpus Christi Bay. Kinney and his partner, William Aubrey, made full use of Padre and its beaches for receiving contraband. The city of Corpus Christi now stands on the site of the old trading post.

As Texas prepared for statehood, General Zachary Taylor was dispatched by President Polk to establish the Rio Grande River as the official border between Texas and Mexico. Taylor set up an encampment in Corpus Christi. The General's forces then moved south to Port Isabel; the main contingent marched along the mainland, while a group of Texas Rangers rode horseback down Padre Island. A supply base at Port Isabel was named Fort Polk in the President's honor. Taylor fought and won two battles north of the Rio Grande. One was at Palo Alto (west of Port Isabel) and the other on the outskirts of Brownsville. The army was then moved across the river into Matamoros where it remained until the signing of the treaty of Guadalupe Hidalgo. This treaty firmly set the boundary between Texas and Mexico.

The end of the Mexican–United States War brought with it the establishment of Port Isabel as a port and a gateway to the "Far West" through the Brazos Santiago Pass. The Gold Rush of '49 found thousands of prospectors riding the steamboats of Richard King and Mifflin Kenedy up the Rio Grande to Laredo. This venture brought King and Kenedy the beginning of a fortune which was to result

in the creation of two of the greatest ranches of all time.

The Port Isabel trade also attracted John Singer and his wife. The Singers were caught in a sudden storm on their journey to South Texas and shipwrecked on Padre Island. Using what they could of salvaged supplies and gathered driftwood, they established a permanent home near the old Balli ranch headquarters at Santa Cruz. Their family expanded and flourished until the onset of the Civil War. Before the family fled the island they buried their valuables in a sand dune. Their treasure was never recovered even though the Singers searched for it several years later. Many adventurers still hope to stumble across the dune now known as "Money Hill".

At approximately the same time that the Singers were settling the southern tip of the island, two brothers, Joe and Uriah Currey, were founding a colony 17 miles from the northern tip of Padre. Other individuals made attempts at island residing but met with little success.

During the Civil War, Padre once again became of strategic military importance. Union gunboats turned toward the Texas coast after bottling up the East and Upper Gulf Coast ports. Brazos Santiago Pass had become a loading base for blockade runners and was immediately closed up by the Union fleet. The Confederates did succeed however, in using the Rio Grande as a back door for shipping cotton.

When Texas seceded in February, 1861, Colonel John Ford routed the Union forces from Port Isabel and soon had control of the coast from Corpus Christi to the Rio Grande. By June of that year the Union had extended a blockade along the whole Texas coast and the only route open for cotton shipment was through Mexico. The city of Bagdad, ten miles from Padre Island, became the critical shipping point. Bagdad had originally been built by Lafitte and his pirates. Union forces began hammering away at the Gulf Coast, particularly Padre Island. The fleeing ranchers succeeded in moving everything that could be moved and in the process the island cattle herds were destroyed. Fighting did not cease on Padre until 34 days after Appomattox.

From 1870 until 1886, Richard King and Mifflin Kenedy successfully ran cattle on the island. Their operation was destroyed by a storm in 1880 and the project was abandoned in 1886.

Padre became the "dukedom" of Patrick Dunn in 1876. Dunn, a native of Ireland, had worked on the open ranges of Texas. When fences began to make their appearance he searched for unrestricted range and found Padre Island was perfect; with the Gulf of Mexico and the Laguna Madre forming natural barriers, permitting the cattle to roam at will. Dunn legally purchased his Padre acreage and established four complete and separate cattle stations. It was near the northernmost of these stations that Dunn built his first home in 1884. The house was of two-story construction made of beach salvage. South American mahogany and Louisiana pine planks were utilized as well as wine casks and furniture from wrecked steamers. The doorsteps were of coral and doors had hinges from a ship's refrigerator room. While Dunn's cattle empire dominated Padre Island, other men of vision were also attempting coastal development.

Colonel Elihu Ropes had plans for a railway which was to run the length of the Gulf Coast to Central and South America. The Panic of 1893 put an end to Ropes' railroad aspirations as well as his plans for a deep water channel through Mustang Island and land development at Corpus Christi.

The close of the 19th century brought hopes of deep water channels at Brazos Santiago (the south tip of Padre) and Port Aransas (the north tip of Mustang). Work was sporatic as starts were made in 1879 and 1897 at Aransas and in 1882 at Brazos Santiago.

The early 1900's were a serene and comparatively calm era for Padre. Further south, however, Mexico was seething with revolution. The Gulf of Mexico was the mainstream for shipments of guns and supplies.

The 600 ton Mexican steamer, Nicaragua, was wrecked on the shores of Padre in 1912. There are several conflicting stories concerning the ill-fated ship. The most romantic of these was the theory that the Nicaragua was a gun runner loaded with guns hidden in sacks of cement. Mexican spies supposedly slipped aboard, sabotaged the steering gear, and ran the ship aground. H. Cyrus Farley, a shrimp boat captain from Aransas Pass, relates a completely different story. According to Farley, who helped with the actual salvage operations, the Nicaragua was strictly a banana boat. The attempt to get the ship afloat was a total failure and the rusting remains can still be seen today, just a short distance from the Port Mansfield channel.

MODERN TIMES

The age of the automobile and the construction of a causeway connecting Padre Island to the mainland brought tourism to the island. The causeway was a brainstorm of Colonel Sam Robertson, who purchased the land from Pat Dunn. Robertson opened the thoroughfare to the public on July 4, 1927. Those expecting a leisurely drive though, were due a surprise. The causeway was built of timber and was comprised of two sets of two troughs set just far enough apart to allow Model T wheels a snug fit. Low guard rails provided little protection for a vehicle that might bounce out of its trough. The wooden supports of this causeway are still visible across the flats of Laguna Madre. Robertson also operated two ferry crossings, one at Port Aransas, the other at Port Isabel.

It was while staying at Robertson's hotel on south Padre in 1931 that Charles Hardin and his wife found the site of the "Lost City of Santa Cruz". They unearthed English and Spanish coins, silverware and other relics. Hardin probed the area on several successive trips and much interest in the history of the old Balli ranch and the Singer home was revived. Santa Cruz is located 26 miles north of Padre's southernmost tip, not far from what is now the south entrance to Padre Island National Seashore.

The later years of the 1930's found many land developers interested in the tourist potential of Padre. The building of a new causeway was sought as well as legal title to the land itself.

The original land grant to Padre Island was for an area of only 11½ leagues while Padre actually covered 30 leagues. The State of Texas sought ownership of the extra acreage. Private ownership was upheld in the courts in 1936 and the court's decision has been the basis for settling all boundary disputes since then.

World War II curtailed Padre's development and the

hopes of many enterprising businessmen lay dormant until 1950.

A new causeway to the north end of Padre Island opened that year, followed a few years later by one at the south end of the island. Land investments followed, as well as plans for parks, hotels and homes.

In 1954 the National Park Service recommended establishment of three National Seashores. One of these was Padre Island. The approval of Congress necessary for the transfer of state lands and acquisition of private property took nine years. Padre Island National Seashore Park became a reality in 1963. Since then millions of visitors have enjoyed the island's beaches and surf and have searched its sands for buried riches. Some treasure hunts have been successful.

In 1967 the remains of a ship suspected to have been one of the Spanish flotilla that left Vera Cruz in 1553, the ill-fated fleet that only Fray Marcos de Mena and Vasquez survived, was discovered by amateur treasure hunters. Of the 47,000 pounds of material recovered, which consisted of cannons, cannonballs, crossbows, chains, astrolabes (the forerunner of the modern sextant), gold, silver and jewelry; all now is in the custody of the State of Texas. Further exploitation by amatuers has been forbidden and the State intends to direct recovery in a more professional manner to prevent the loss and destruction of this historical find.

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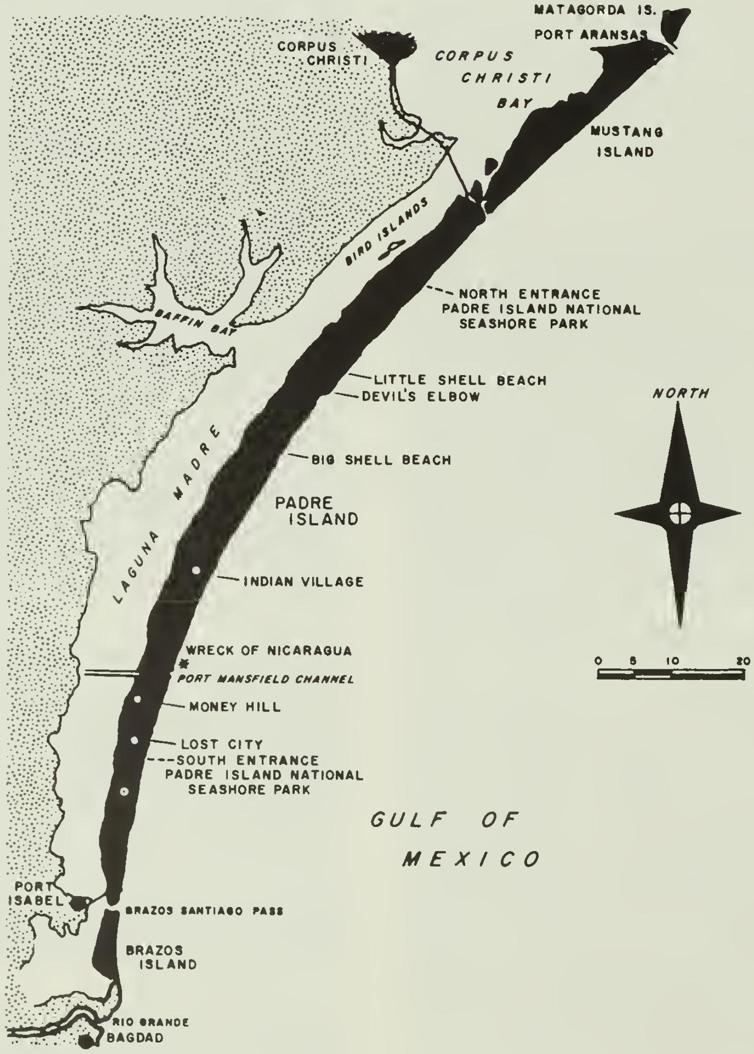


Betty Callaway, housewife and mother, is interested in the history of the area and is a lover and habitué of the island. She majored in English at the University of Minnesota, and is married to Dave Callaway, one of our society members.

SHELL COLLECTING IN THE PADRE ISLAND NATIONAL SEASHORE

Jean Andrews
Corpus Christi, Texas

The very names, "Little Shell" and Big Shell," conjur up visions of beaches laden with seashells both large and small. These two portions of the Gulf shore, lying within the boundaries of the Padre Island National Seashore, have long been siren songs to those who dreamed of collecting shells on the white sands of that great barrier island which stretches its narrow barrens for one hundred and thirty three miles along the coast of arid South Texas from Corpus Christi to Port Isabel.

For years the inaccessability and remoteness of these regions only enhanced their lure. The fury of a hurricane destroyed the only access to Padre Island in 1933. From that howling day until a calmer, more brilliantly lit afternoon in 1950, when the new Kenedy causeway was put into operation, the beaches of Little Shell and Big Shell were only unattainable dreams to all but a few leathery fishermen. Then for a brief period from 1950 to about 1963, the lucky owner of a warworn jeep or some other four-wheel-drive relic could hazard the trip to those remote shores and reap their sea born harvest of beach-stranded treasures. But alas, with the easy availability of the four-wheeled-drive vehicle to our affluent society the isolation, so treasured by those few hardy souls and their lonely companions, the pristine seabirds, was gone forever.

Padre Island is the longest barrier island in the world. Prior to the opening of a jettied pass opposite Port Mansfield in 1962, thirty-eight miles north of the Southern tip, one could drive its entire length in such a solitude that it took little imagination to transport one to the surface of the moon. The rolling, rippled dunes, the salt-glistening washover flats, the chilling howl of a coyote, the total isolation, all added to the effect of other-worldness. It had a strange desolate beauty that was tinged with enough eerie danger to make it an unforgetable experience to those who knew it then—only a few short years ago.

Beachcombers have always felt that if they could just get "way down" Padre Island to Little Shell or Big Shell, there they would find a wonderland of shells. Yes, he would find shell, tons of shell, but all broken—that is, unless the adventurer came after a storm or similar Gulf disturbance. So, don't feel bad that you did not get there in the good old days; it was little different except that you had the pickings of an accumulation all to yourself. Today the traffic is such that sealife and wreck does not have a chance to accumulate. We will attempt to explain why the casual collector doesn't find that beautiful "conch" waiting for him at Big Shell.

Padre Island is not unique in having a few living molluscan (shell) inhabitants because this is a universal characteristic of open, unprotected water. The substratum here is sandy and shifting; the water is turbulent; the temperature reflects that of the air. An unprotected sandy beach is sparsely populated by a few forms of burrowing animals and is not the place one can expect to find more than a few species of live mollusks, except after a storm or a hard freeze when inhabitants of the open shelf are stranded on the beach. Two major forms may be found: a small auger snail *Hastula salleana* (Figure 1a) and the colorful butterfly coquina *Donax variabilis texasiana*, which quickly burrow into the wet sand after each receding wave. (Figure 1b)

The only two mollusks living in the surf zone of Padre Island beach are the little, drab colored auger snail *Hastula salleana* Deshayes and the colorful butterfly clam *Donax variabilis texasiana* Philippi called a "Coquina" which may be found burrowing into the wet sand after each receding wave.

Little Shell begins about twenty miles south of Bob Hall Pier and extends to a point about three miles beyond Yarborough Pass (28.3 miles). For the next ten or twelve miles driving is through Big Shell, where it will be quickly noticed that the beach is composed of large heavy shell fragments.

The barrier islands are parallel to two or three rows of sand bars with troughs between them that are called longshore bars and longshore troughs. One difference in the foreshore of mid Padre Island is that the longshore bars do not parallel the shore, but form what the fishermen call "blind guts" along the shore. The absence of the bars also accounts for the area called Big Shell. Without the bars the full force of the waves strikes the beach, fragmenting all but the large heavy shell so characteristic of this stretch of shore. The probable reason for the absence of sand bars is the abrupt curve that the coastline makes in this mid-region. It not only changes direction in relation to the prevailing winds but also becomes the meeting place of the longshore currents.

The sea shell you find along the high tide line of the beach is exo-skeleton of a marine animal. These soft-bodied animals called mollusks (L. *mulluscus*-soft) lack internal skeletons. Instead, they secrete a calcareous substance which hardens to form a shell. As the animal grows, it adds to its shell, layer by layer, throughout its life. These successive periods of growth and rest may be observed on the shell by rings or ridge-like "growth lines." Usually the animal that constructed the shell one finds on the seashore has long beed dead, and the shell has been rolled by the waves until it is hardly recognizable. The collector who finds a live shell considers himself fortunate.

The mollusk takes many forms including the legendary octopus, the jet-like squid, the primative chiton, and the tapered tusk shell; but only two types occur on the Texas coast in sufficient quantities to concern the beginning collector. These are BIVALVES–clams, oysters, scallops, and mussels and GASTROPODS or snails and limpets. The bivalve shell consists of two valves joined together along one margin by a leathery hinge. This hinge is easily broken, and the waves quickly separate the two halves after the animal, which they enclose, dies. Fewer species of bivalves than gastropods exist but they occur in greater number than do the snails.

BIVALVES

The bivalve is a mollusk which requires a watery habitat, either marine or fresh water. The soft parts of the animal are enclosed within two hinged shells. These two shells or valves are opened and closed by one or two large adductor muscles. At the anterior end of the shell the foot is located. This foot is well developed in clams that burrow into the substrate, but is small in attached forms such as the oyster and mussel. The posterior section of the mantel is the location of the two siphons which carry food and water into the mantle cavity and expel the wastes back into the water.

Clams spend most of their lives in burrows but can move about slowly with their muscular foot. The oyster and jingle shell cement themselves permenently to one spot. Mussels, arks, and pen shells attach themselves by means of a thread-like byssus, while the scallop remains free-moving and skips about by means of jet propulsion. The bivalve is the most commercially valuable of all classes of mollusk.

GASTROPOD

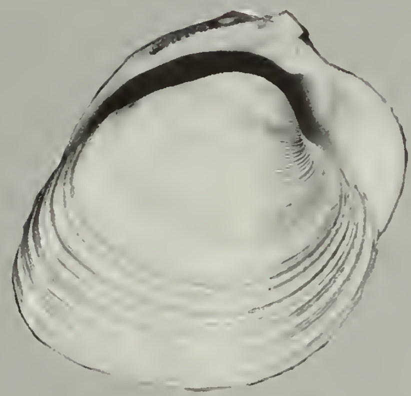
The gastropod or snail has a single spiral shell, a foot, a head, long tentacles, a snout and a rasp-like tongue or radula. It is a free moving animal and inhabits land as well as both fresh and marine water. Many snails are carnivorous and prey on the hapless clam. Evidence of this predatory trait may be seen in the perfectly round holes which they drill in the shell of a bivalve in order to suck out their victim. Others feed by extracting food from water which is drawn into its body by means of the siphon. Most snails, but not all families, have an operculum or trap door attached to the bottom of the foot. The operculum may be horn-like or calcareous and is used to seal up the aperture of the snail shell when the animal withdraws into its shell. The "true" collector does not consider his snail speciman complete unless he has the operculum as well as the shell.

Approximately three-hundred and fifty species of sea shell may be found on the Texas coast. About one half of these are very minute and may be easily overlooked by the casual collector. There are about thirty or forty species commonly found by the beachcomber; these are illustrated and identified here. Of course, a sharp eye may spot some of the less conspicuous varieties, or one might be lucky enough to find our most sought after shell, Mitchell's Wentletrap *Amaea mitchelli*, (Figure 2) which is found only on the Texas and Mexican coasts. Whether one strikes a windfall or not, one will have collected a true marvel of nature–the sea shell, a gift from the sea.

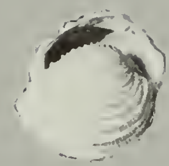
The most sought after shell on the Texas coast, Mitchell's Wentletrap (Amaea mitchelli Dall) that can only be found on the gulf coast of Texas and Mexico.

BIVALVES

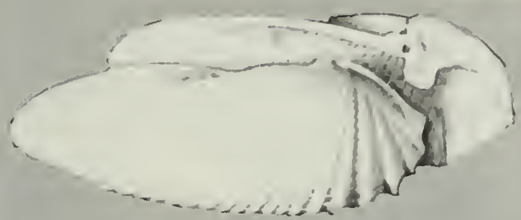
SPINEY JEWEL BOX
Echinochama cornuta Conrad
Length 1 to 1½ inches



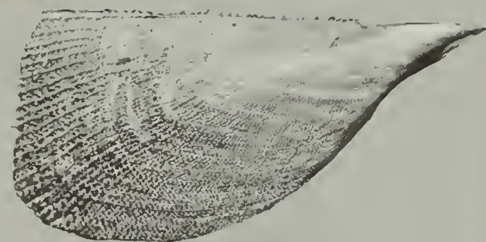
SOUTHERN QUAHOG
Mercenaria campechiensis Gmelin
Length 3 to 6 inches



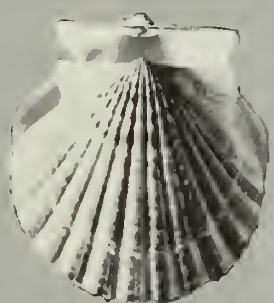
CROSS-BARRED VENUS
Chione cancellata Linné
Length 1 to 1¾ inches



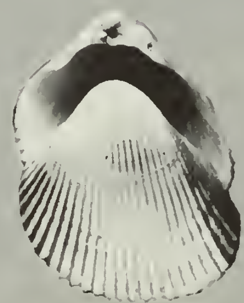
ANGEL WING
Cyrtopleura costata Linné
Length up to 7¼ inches



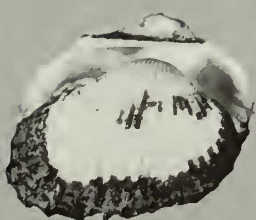
PEN SHELL
Atrina serrata Sowerby
Length up to 11½ inches



ATLANTIC BAY SCALLOP
Aequipecten amplicostatus Dall
Diameter 2 to 3 inches

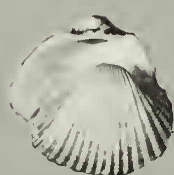


GIANT ATLANTIC COCKLE
Dinocardium robustum Solander
Length 3 to 4 inches

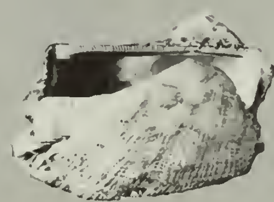


TRANSVERSE ARK
Anadara transversa Say
Length ½ to 1½ inches

INCONGRUOUS ARK
Anadara brasiliana Lamarck
Length 1 to 2½ inches



BLOOD ARK
Anadara chemnitzi Philippi
Length about 1 inch

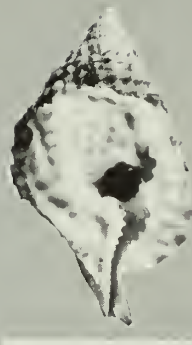


MOSSY ARK
Arca umbricata Bruguiére
Length up to 2½ inches

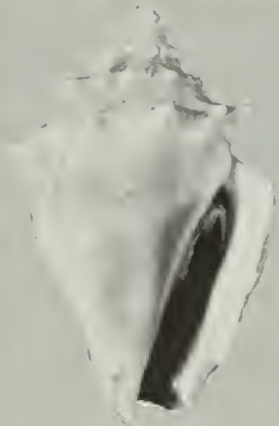
GASTROPODS

ROCK SHELL
Thais haemastoma floridana Conrad
Length 2 or 3 inches

BANDED TULIP SHELL
Fasciolaria hunteria Perry
Length 2 to 4 inches



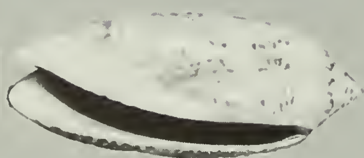
ATLANTIC DISTORSIO
Distorsio clathrata Lamarck
Length 1 to 3 inches



FIGHTING CONCH
Strombus alatus Gmelin
Length 3 to 4 inches

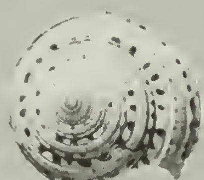
SHARK'S EYE
Polinices duplicatus Say
Length 1 to 2½ inches

SCOTCH BONNET
Phalium granulatum Born
Length 1 to 4 inches

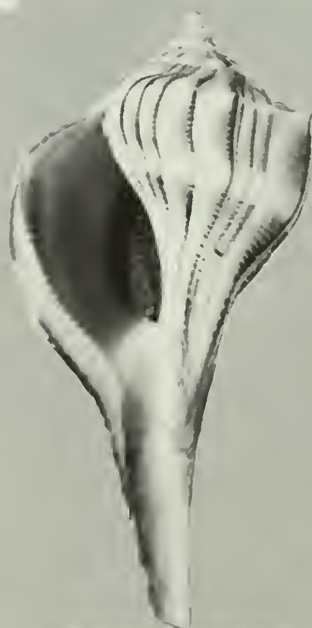


LETTERED OLIVE
Oliva sayana Ravenel
Length 2 to 2½ inches

KEYHOLE LIMPET
Diodora cayenensis Lamarck
Length 1 to 2 inches



SUNDIAL
Architectonica nobilis Roding
Diameter 1 to 2 inches



LIGHTNING WHELK
Busycon contrarium Conrad
Length 4 to 16 inches

Jean Andrews, author, artist, naturalist and teacher, is an internationally recognized authority on the shallow water marine shells of Texas. Her paintings have been exhibited in major shows throughout Texas, New York and Washington and are located in many of the most important collections in Texas. Her accomplishments in flower arranging and gardening are widely known and she is a Master National Flower Show Judge. Photography is just one of her many activities and her skill may be judged by the accompanying shell photography.

Ms. Andrews – who may be the only woman to drive every inch of the Texas beach and on into Mexico – is an avid skin diver, bird watcher, conservationist, and a talented gourmet cook. This resident of Corpus Christi is a graduate of the University of Texas and holds a Master of Science degree.

Of her recent book, "Sea Shells of the Texas Coast", University of Texas press, it has been siad . . . "This book is a milestone in the knowledge of the natural history of the Texas coast. It sets a new, higher standard for all future popular works on regional malacology". (Veliger Vol. 14 (4). Frank Tolbert in the Dallas Morning News stated "It is the best general book I've read – scientific or popular – on this state's 367 miles of Gulf of Mexico shore. What a book! A work of love".

BIRDS OF PADRE ISLAND

by J. Michael Endres
Corpus Christi, Texas

LAUGHING GULL – *Lárus atricilla*

Probably the most common bird on the Texas bays and beaches, the Laughing Gull has adapted itself well to the ways of man. It is at once a beggar and scavenger on the beaches, in the cities and on the farming land near the coast.

The Laughing Gull is sometimes called the sexiest bird on the Texas coast, and this one believes it to be so . . You will see it during the nesting season with a black head and mandibles. The mouth is lined with brilliant red. It molts with the winter season to a nondescript grey and you may think you are looking at a different bird.

MOCKING BIRD – *Mimus polyglóttos*

The state bird of Texas, the Mocking Birds establish territories and defend them against all comers, including man. It has been known to inflict rather serious wounds on the head and neck of humans who intrude when young are on the nest. Its song at midnight, morning, afternoon and evening is worth the trouble of putting up with its arrogance.

LONG BILLED CURLEW – *Numenius americánus*

This is another bird that has adapted itself well to the habitat of man. Man made parks and golf courses are the regular haunts of the Long Billed Curlew. You will also see it along the causeway to Padre Island, poking its long curved bill, with the little hook on the end, down into the soft sand for crustacea.

LOGGERHEAD SHRIKE – *Lanius ludovicanus*

The scientific name means "a butcher from Louisiana" and the bird has the common name "Butcher Bird". The shrike resembles the Mocking Bird in that it sets up its own territory and defends it viciously. It has a small hook on the end of the upper mandible like a hawk and has a unique practice of impaling small rodents, large beetles and small birds on long thorns. It then skins its prey and proceeds to eat it; hence "Butcher Bird". You will see these birds in city gardens, in open country along the road side, and on Padre Island.

KILLDEER – *Charadrius vociferous*

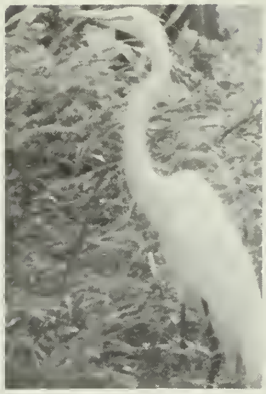
If you see a bird with two bold, black and white frontal bands, which runs, pauses, and runs again, you are probably looking at a Killdeer. It ranges widely and inhabits both the open beaches and the prairies. During the nesting season it lays its eggs in exposed spots. The birds are watchful parents and at the first hint of possible danger they raise such a clamor that their scientific name, which means "Noisy Plover", is quite apt.

CATTLE EGRET – *Bubulcus ibis*

A native of Africa, this white egret suddenly appeared in northern South America, after negotiating the Atlantic Ocean with the help of strong wind currents and storms. You may see them in vacant lots in cities and on the open range in company with cattle, feeding on the insects stirred up by the beasts movements. The scientific name means "Cattle's sacred bird".

THE PEEPS – *Erolia and Chacethia alba*

These are the little active birds which advance and retreat with the waves along practically all beaches. The groups are composed of several kinds of small Sandpipers and Sanderlings. The quick little birds feed on small crustacea and worms on the beaches, and on insects and their larva on the tidal flats. Gregarious and sociable, they share the beaches with humans. When approached, they fly up in closely knit groups and follow a small arc, alighting quickly a few yards down the beach. The scientific name means "Sandpiper" and "White shore runner".



AMERICAN EGRET – *Casmerodius alba egrette*

Common along the Oso, the Laguna Madre, salt and fresh water marshes and mud flats, the stately American egret stands statuesquely waiting to spear a fishy meal. Larger than the Snowy, it is identifiable by its large size, its yellow bill and its black legs and feet. The species is gregarious and is usually found in small flocks accompanied by Snowy egrets and other marsh birds which feed on muddy sea shores or in grassy swamps.

SNOWY EGRET – *Leucophoyx thula*

The Snowy is smaller than the American Egret and can easily be distinguished from it by the slender black bill, and black legs which end in yellow feet, commonly called the Snowy's "golden slippers". The Snowy is very gregarious and nests and feeds in colonies with other herons and egrets. At the turn of the century, because of their beautiful aigrettes (the long delicate feathers on the back which are raised and lowered during the mating show), the Snowy was almost wiped out. By protective laws and conservation methods, they were saved and are now on the increase. You will find it in the shallow bays and salt marshes, feeding by stirring the water with its little golden slippers to disturb crustacea, insects, frogs and other small aquatic life.

LOUISIANA HERON – *Hydranassa tri-color ruficollic*

The Louisiana Heron, slate gray with little white britches, is sadly misnamed. It breeds in the open marshes and mud flats all across southern United States, Mexico and Central America. It can be seen in the Oso, the Laguna Madre, and along the causeway to Padre Island. While feeding, it is as active as the Snowy Egret, walking quickly through the shallows, suddenly flourishing a wing to shadow the water and to frighten its intended meal. "The Water Queen" (Hydranassa) consumes great quantities of trash fish and aquatic insects.

REDDISH EGRET – *Dichromanassa rufescens*

Once decimated by plume hunters, the Reddish Egret is slowly increasing in numbers. This bird is a coastal species, feeding in the shallows over mud flats. As you drive along the causeway to Padre Island, be alert for a dark heron, shaggy of head and neck, with a bill which is dark at the tip and flesh colored at the base. The Reddish is usually active and unpredictable as it feeds, lurching and stumbling about and using the spread wing technic for frightening and capturing fish. Its staggering, running, stopping, banking, stumbling method of capturing small illusive fish is, in itself, one of the easily recognized field marks of this bird.

GREAT BLUE HERON – *Ardia heródias*

The Great Blue Heron is a common sight along the causeway to Padre Island and on the open beaches or mud flats. It stands four feet tall and has a wing spread of seventy inches. In flight it carries a crook in its neck which is caused by neck vertebra of unequal length. The Great Blue has attained the age of twenty five years. It catches food by wading slowly through shallow water or patiently waiting for an unwary fish or frog. Herons nest in colonies on islands in the bays and inlets. Sometimes the nest is on the ground, but if trees are available they will use the high branches. They tend to feed alone and will drive away another Blue Heron which tries to intrude on a favorite fishing spot.

BLACK SKIMMER – *Rýnchops nigra*

The black tipped, knife thin, red bill with its elongated lower mandible, and the white edged black wings are distinctive field marks. Skimmers are usually confined to the coastal regions of North America. These spectacular birds feed by cutting the surface of the shallow water with the lower mandible. The jaw is hinged at the top and special vertebrae keep the bird from breaking its neck in case of collision with a fixed object under the surface of the water. The fishing sorties occur in the early morning and at dusk. The Black skimmers along the Padre Island beaches eventually lose the difference in mandible length due to the abrasion of the sand.

These birds are quite common and gregarious. Sizeable flocks of them will be seen nesting all along the west side of the causeway leading to Padre Island. The nest is a scraped depression in the shell and sand just above the tide level. In June and July eggs are laid. Four buffy white eggs are a normal clutch. Both parents incubate the eggs and feed the young.

WILLET – *Catoptróphorous semipalmatus*

Commonly called "Stone Curlew", the Willet is a coastwise bird, seldom seen away from coastal marshes, beaches and islands. Noisy and demonstrative, they are called "Tattlers" because, if danger threatens, they raise such an outcry that they warn the entire swamp. The Willet feeds on aquatic insects, marine worms, small crabs, mollusks and fish. The flight of the Willet is most spectacular. It is then that the drab nondescript bird exposes its uniquely patterned black and white wings. The scientific name means "Carrying a mirror (because of the flash pattern of the wings) and Half webbed".

WHITE PELICANS – *Pelecánus erythrorhýnchos*

Hundreds of these large white birds live in the Oso estuary and may be seen while driving out to Padre Island. They are usually visible from the bridge across the Oso, on Padre Island Drive just north of Flour Bluff, and also may be seen in the waters along the causeway to the Island. They feed in groups of from 10 to 12, herd small fish inside the group circle, then scoop them up with their seine-like bills. You may see the White Pelican soaring and scaling with a light atmospheric thermal. In flight they are recognizable by the great wing spread and the beautiful black and white pattern of the undersides of the wings.

CASPIAN TERN – *Hydroprógne cáspia*

Even the scientific name is interesting.

Hydro, water – Prógne – Pandions daughter who was turned into a swallow.

THUS: Water swallow of the Caspian.

If you should see a bird, hovering over the water, bill pointed downward, which plunges headfirst into the depths, it is most likely to be a tern. The Caspian tern, streamlined, with a forked tail, can be seen at most any time on Padre Island and certainly deserve the name "Water Swallow". Several species of terns inhabit the area, but a slightly crested black head, a stout coral bill and stocky build are field marks which readily identify the Caspian. It travels about singly or in small groups and may be seen resting on open beaches.

GREATER YELLOWLEGS – *Totanus melanoleúcus*

The big Yellowlegs is common to nearly every area suitable to shore birds in the Western Hemisphere. In the Padre Island area, they may be observed feeding in the shallow water of the Oso, on tidal flats, and on the beach. They seldom probe in the mud but run about chasing fish, tadpoles, crustacea, and aquatic insects. The Greater Yellowlegs is not inclined to gather into flocks, and though they scatter out when feeding, they will often be in association with other shore and marsh birds. This bird too, is a "tattler" and sounds a loud alarm at the approach of probable danger.

SANDHILL CRANE – *Gruss canadensis pratensis*

About the size of, or perhaps a little larger than the Great Blue Heron, the Sandhill Crane is smoke gray with a bare red head. Herons fly and stand with an "s" curve in their necks but Cranes walk, fly and stand with necks straight. This is most noticable during flight. Lucky birders have seen small flocks of Sandhill Cranes ranging over the dunes on Padre Island. The Sandhill Crane, unlike the Whooping Crane, has fared well with civilization. Its food supply is vegetable and its wide range, in this part of Texas, includes the pasture lands of the great cattle ranches, and the cut over maize fields.

J. Michael Endres FPSA, Hon. JPS, is a Fellow of the Photographic Society of America, a Three Star Exhibitor in Photographic Salons, and has served as a judge many times in International color, nature and black and white Photographic Salons. He has presented well over five hundred talks, lectures, slide shows and programs, several at International Conventions of PSA. His great interest in nature photography and the wealth of birdlife in this area has lead him to specialize in bird photography which he considers a greater challenge than hunting with a gun. His pictures are made with Leica and Canon cameras using lenses ranging from 20 mm wide angle to 1000 mm telephoto. He is a member of the Audubon Society, The Corpus Christi Camera Club, and the Nature, Color, and Pictorial Divisions of the Photographic Society of America. Mr. Endres is a retired Sinclair Landman, and an Honorary member of the Corpus Christi Landman's Association.

CRUSTACEANS OF PADRE ISLAND, TEXAS, AND ADJACENT WATERS[1]

Gary W. Hill
U.S. Geological Survey, Corpus Christi, Texas

INTRODUCTION

The crustaceans of Padre Island and adjacent waters are a diverse group of organisms found on the beach and in the brackish ponds of the island, in the normal marine environment of the Gulf of Mexico and in the brackish to hypersaline environments of Corpus Christi Bay and Laguna Madre. This paper will describe only a few crustaceans which, due to their size, abundance, or commercial value, are easily accessible to the casual observer. Crustaceans fitting this criteria include barnacles, shrimp, and crabs.

BARNACLES

The barnacle, a hard shelled animal that more nearly resembles a mollusk than a crustacean, grows on pier pilings, jetty rocks, drift wood, shells of mollusks and sea turtles, and other hard surfaced objects. Unlike most crustaceans, the adult barnacle lives a sedentary life. The acorn barnacle (*Balanus* spp., fig. 1) and gooseneck barnacle (*Lepas* spp., fig. 1) occur commonly in all waters adjacent to Padre Island. Although the cost of scraping barnacles off ship hulls and pilings might seem to give them a negative commercial value, their value as a food source for many important fish species more than offsets this.

SHRIMP

Of the many species of shrimp living in the waters adjacent to Padre Island, only a few, those belonging to the genera *Penaeus* and *Palaemonetes*, are common enough to be found by visitors to the Padre Island area.

Because of their use as human food, the brown, pink,

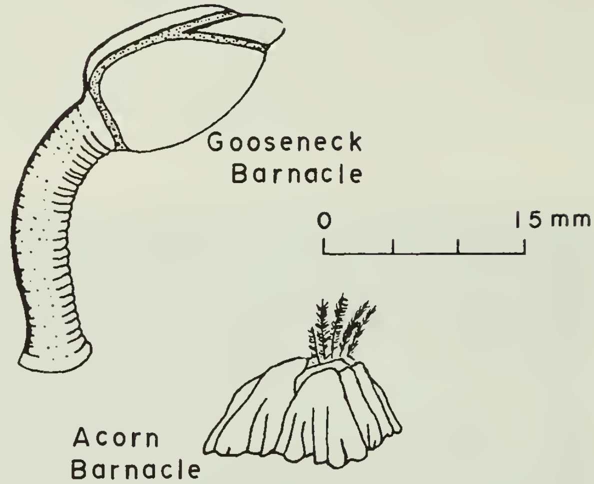


Fig. 1 – Barnacles common to the waters adjacent to Padre Island (modified after Pimentel, 1967)

and white shrimp (*Penaeus* spp., fig. 2) are the shrimp species most commonly seen by the casual observer. The factors which make these peneid shrimp commercially valuable are their abundance, size, and occurrence in shallow waters during part of their life cycle. The annual catch of peneid shrimp along the Texas coast is about 64 million pounds, worth more than $25 million (Moffett, 1970). These shrimp are larger than most species; the female white shrimp, for example, weighs as much as 3 ounces and grows to a length of 10 inches. Both the Gulf of Mexico and Laguna Madre are used by the peneid shrimp

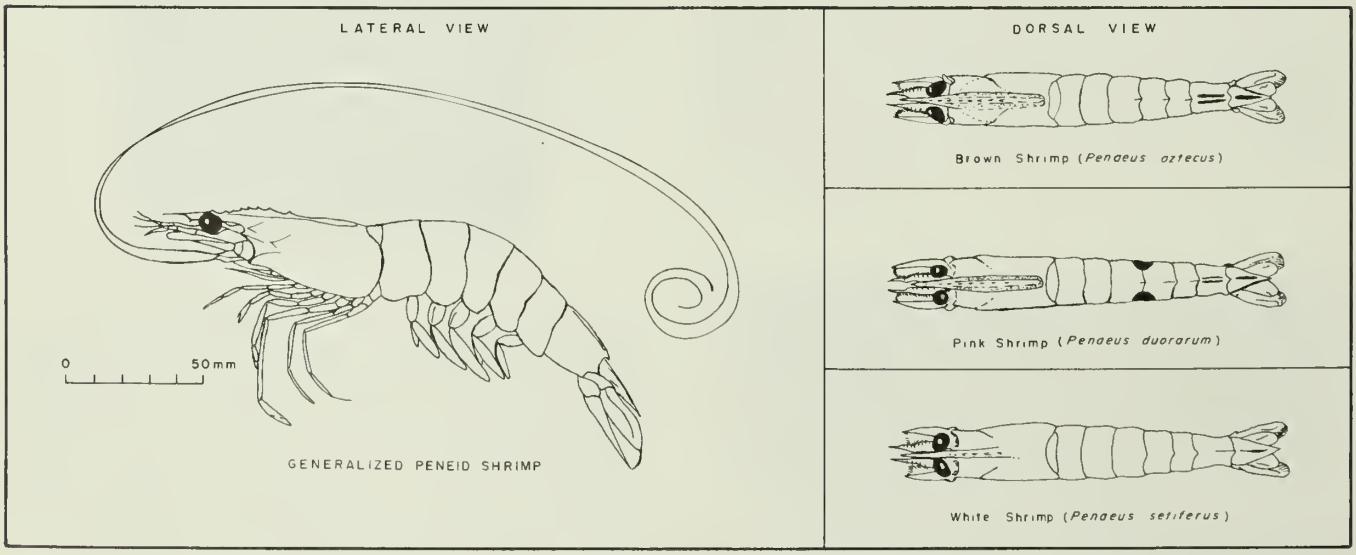


Fig. 2 – Peneid shrimp common in the Padre Island area (modified after Moffett, 1970)

[1]Publication authorized by the Director, U.S. Geological Survey

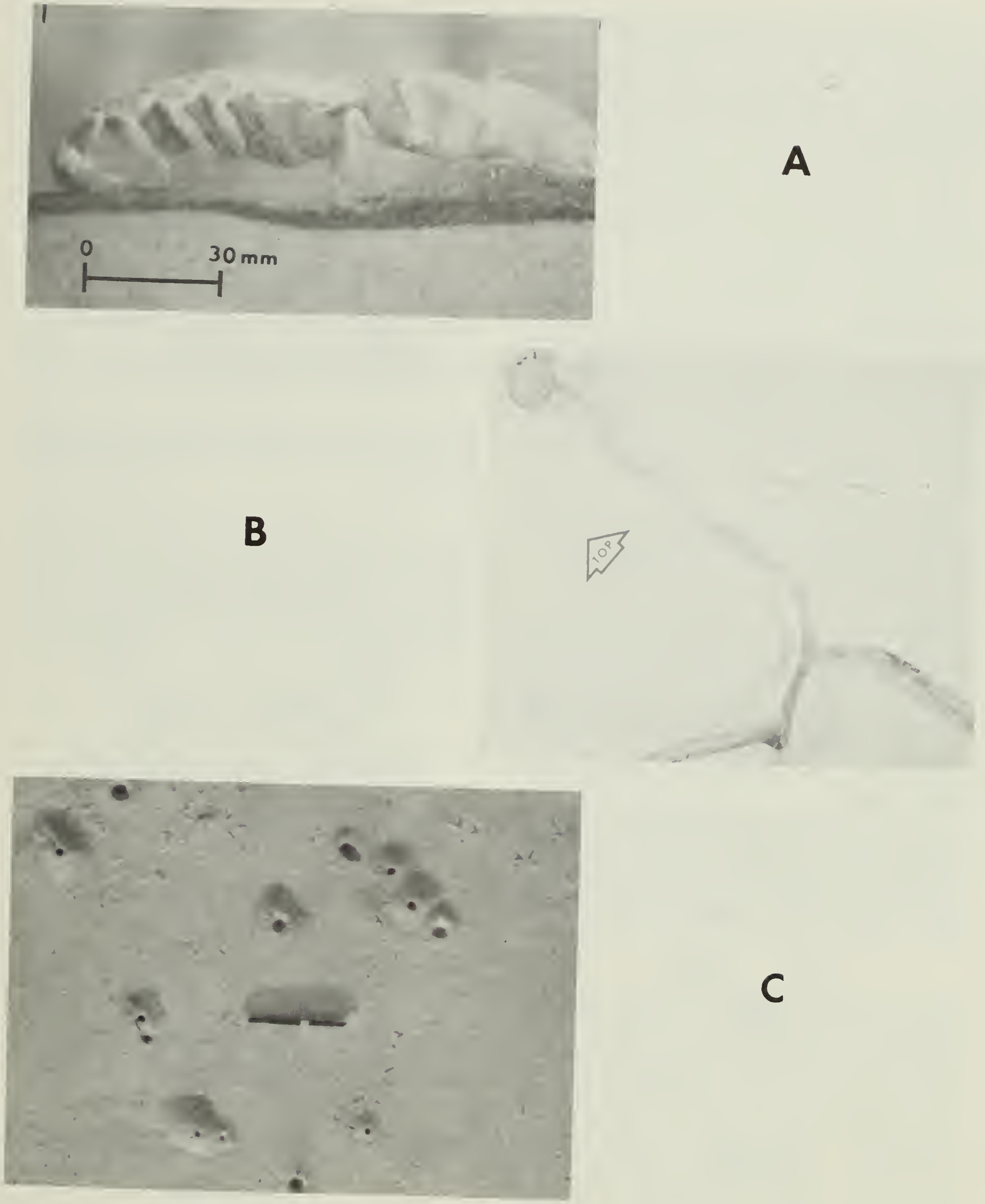


Fig. 3 – A. Lateral view of gravid female ghost shrimp. B. Epoxy cast of main section of ghost shrimp burrow. C. Surface openings to ghost shrimp burrows.

in completing their life cycle. The adult shrimp spawns in the open Gulf, and the larval forms swim and are transported by currents into the brackish waters of the Texas bays and Laguna Madre, which serve as nursery sites. Within the nutrient-rich nursery areas, the shrimp grow rapidly and soon reach maturity. This new crop of adult shrimp migrate back to the open Gulf to spawn and start the cycle once more.

"Grass" shrimp belonging to the genus *Palaemonetes* are abundant in Laguna Madre. These shrimp, which resemble the peneids in shape, are small, less than 2 inches long, and hold no commercial value.

CRABS

GHOST SHRIMP

The crab of the anomuran tribe commonly called the ghost shrimp looks, as the common name implies, more like a shrimp than a true crab (fig. 3A). Living in deep multibranched burrows (fig. 3B), the ghost shrimp (*Callianassa islagrande*) is abundant on the lower foreshore of the sandy Gulf beaches of Padre Island. Although the crab lives a secluded life and is rarely seen, the surface openings to the burrow system (fig. 3C) have always intrigued visitors to the beach.

The ghost shrimp's burrow holds geologic interest because its fossilized form *Ophiomorpha* serves as a paleogeographic guide in identifying ancient shorelines.

MOLE CRABS

Living along the water line in the sandy environment of the Padre Island beach, mole crabs (*Emerita* spp.) can be found burrowing in the upper few inches of sand. Unlike the ghost shrimp with its open burrow system, these small anomuran crabs "swim" through the sediment using modified limbs and taking advantage of their streamlined bodies (fig. 4). They are most often seen when washed out of the sand by waves but can also be found by digging.

HERMIT CRABS

The hermit crabs represent a major family of anomuran crustaceans and are abundant in all waters on and adjacent to Padre Island. Because of their soft, asymmetrical, spirally twisted abdomen (fig. 5), which is extremely vulnerable, the hermit crabs live in the empty shells of gastropods (fig. 5). Specially modified appendages enable these crabs to move freely, carrying the gastropod shell with them. This characteristic use of shells as "protective housing" is responsible for the common name of this crab family.

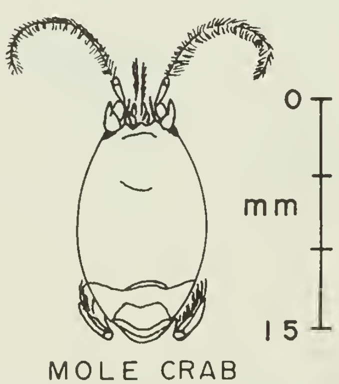


Fig. 4 – Dorsal view of the mole crab *Emerita talpoida* (after Williams, 1965)

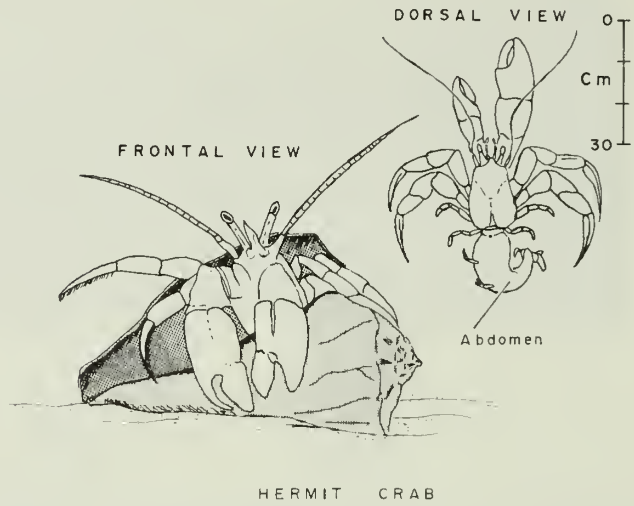


Fig. 5 – The hermit crab *Petrochirus bahamensis* (modified after Leary, 1967)

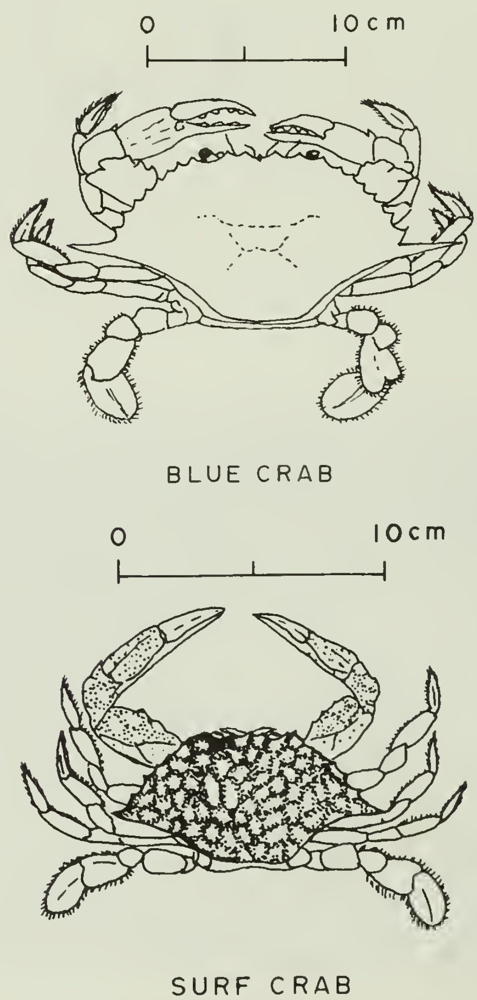


Fig. 6 – Dorsal view of swimming crabs common to the Padre Island area (modified after Leary, 1967)

SWIMMING CRABS

The portunid or swimming crabs include the largest and most commercially important crabs on the Texas coast. They are named for the flattened back legs used in swimming. The blue crab (*Callinectes sapidus*) and the surf crab (*Arenaeus cribrarius*) are two of the more common swimming crabs in the Padre Island area.

The blue crab (fig. 6) is considered the most important crab on the Texas coast because of its commercial value. In 1960, some 2 million pounds of blue crab were landed (Leary, 1967). The species is found in all waters adjacent to Padre Island, but because of a preference for muddy bottoms is more common in Laguna Madre and Corpus Christi Bay.

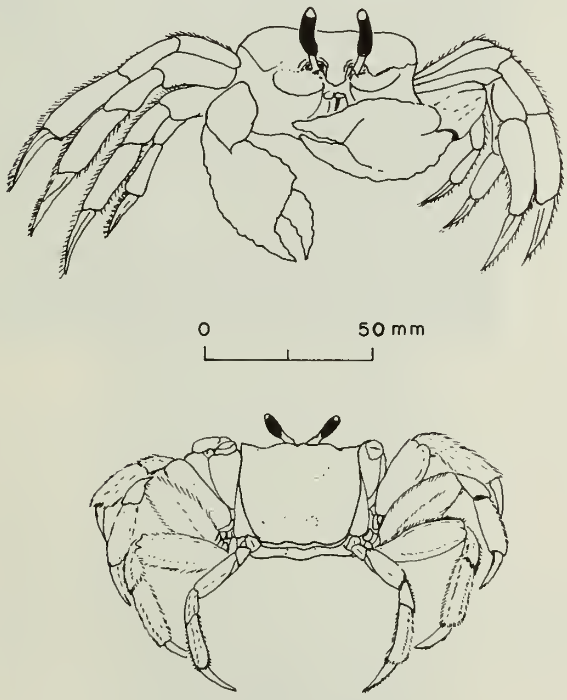
The surf crab (fig. 6) is similar to the blue crab in shape but is distinguished by the color pattern of the carapace (thickly scattered small yellow or white spots on an olive brown background). This species is common in the surf zone of Padre Island, where it feeds on small fish and other crabs.

The carapaces of both the blue crab and surf crab are commonly found strewn along the swash line of the Gulf beaches of Padre Island.

GHOST CRABS

The ghost crab *Ocypode quadrata* (fig. 7) is the dominant marine macroinvertebrate on the Gulf beach of Padre Island. This species lives in burrows whose surface openings dot the beach and foredune ridge. Because of their nocturnal habits, ghost crabs are seldom seen on the beach during daylight hours. At night, however, great numbers leave their burrows to search for food. As ghost crabs are scavengers, large populations exist around areas of human activity on Padre Island where refuse is left.

Like the burrow of the ghost shrimp, burrows of ghost crabs have geologic significance. Burrow morphology, distribution, and orientation can be used to differentiate between subzones of the Padre Island beach and foredune ridge (Hill and Hunter, unpub. manuscript) and therefore have potential use as a paleogeographic guide in identifying ancient beach environments.

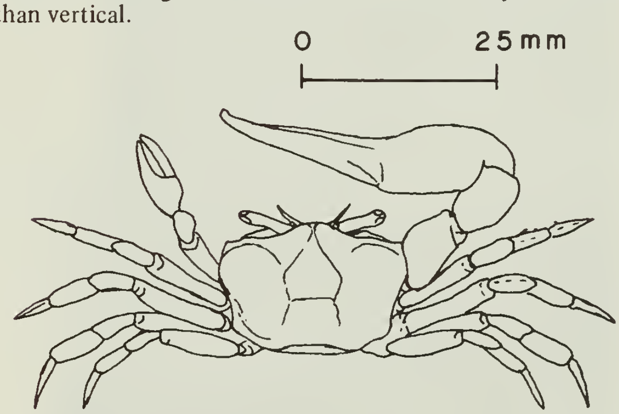


GHOST CRAB

Fig. 7 – The ghost crab *Ocypode quadrata* (frontal view modified after Leary, 1967; dorsal view modified after Williams, 1965)

FIDDLER CRABS

The fiddler crabs (*Uca* spp.) are found around the brackish ponds of Padre Island. These crabs exhibit sexual dimorphism in that the male has one oversized claw (fig. 8), whereas the female's claws are both small. The fiddler crabs live in an open burrow system which, unlike those of the other burrowing crabs discussed, is more nearly horizontal than vertical.



FIDDLER CRAB

Fig. 8 – Dorsal view of male *Uca pugilator* (modified after Williams, 1965)

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Gary W. Hill is a graduate of the University of Corpus Christi where he was a Warren Scholar (4 years), and graduated Summa Cum Laude with a B.S. in Biology. He is a graduate student (Master's Degree program) at Texas A&I University (Biology Dept.). Hill has been presented the Troy Post Young Texan of the Month Award and was runner-up for Young Texan of the Year (1966–Optimist Clubs of Texas). As a student, he began part-time work with the United States Geological Survey and after a tour of duty with the Army began full time employment with the U.S.G.S. in 1971 as a Physical Science Technician. His current work includes study of biological influences on marine sediments and study of coastal water movements off the Texas coast.

COMMON PLANTS OF PADRE ISLAND

Lee Otteni

INTRODUCTION

The purpose of this section is to make available to the interested layman names of, and information about, some of the common and conspicuous plants of Padre Island. It is regrettable that space limitations do not permit descriptions of all the most common plants of Padre Island.

To assist in standardizing names of Texas plants, this paper gives preference to scientific and common names found in **Manual of Vascular Plants of Texas** by Correll and Johnston.

Seaoats (*Uniola paniculata*)

Somewhat resembling oats, seaoats grow on the crests and sides of sand dunes throughout the Island. Largest of the grasses, it can attain a height of six feet. The large dense panicules of broad, drooping spikelets are apparent from June to November. Seaoats presently are the most important plant in stabilizing blowing sand and in forming the barrier dunes.

Saltmeadow Cordgrass (*Spartina patens*)

Saltmeadow cordgrass is commonly called cordgrass or marshhay cordgrass. Vast areas of this grass were burned, to enhance its growth, by cattlemen during the cattle raising era of Padre Island. Cordgrass has thick creeping rhizomes, long tough blades, and usually grows to two feet in height.

Bitter Panicum (*Panicum amarum*)

Expanding its distribution on Padre Island, bitter panicum is predominately found along the beach. As seaoats, this grass is adapted to growing in loose dune sand. It binds the soil beneath it with an extensive system of rhizomes and grows upward through blowing sand which many times buries it.

Beach-tea (*Croton punctatus*)

Beach-tea is also called beach croton. This woody-stemmed, extensively spreading subshrub is found growing on the barrier dunes. It is easily recognized by its distinctive, silvery appearing, ovate leaves.

Goatfoot Morning Glory (*Ipomoea pre-caprae*)

Goatfoot morning glory is also referred to as railroad vine. Its prostrate, rounded, succulent stems crisscross the sandy coastal dunes and beaches. It is called goatfoot morning glory because the shape of the fleshy leaf resembles a goat's foot. The rosy or purple flower, which is two or three inches long, opens in late evening and closes in late morning.

Beach Morning Glory (*Ipomoea stolonifera*)

The beach morning glory is found on the sandy coastal dunes and beaches. Its leaf blades vary from ovate or elliptic to ones with basal lobes. The flowers are white with yellow centers and spread about three inches in diameter.

Partridge Pea (*Cassia fasciculata*)

The seeds of the partridge pea are utilized by bobwhite quail and other birds, but it has been reported to be toxic to stock when the plant is green. It is also occasionally grown as an ornamental. Each oblong leaf has eight to fifteen pairs of linear leaflets, and the flowers are yellow with brown markings at the base of the two lower petals. Also referred to as Prairie senna, it is abundant in the mid-island.

Whitestem Wildindigo (*Baptisia leucophaea*)

A very attractive plant, whitestem wildindigo has stout stems at ground level and becomes bushy-branched higher up. Blooming in the spring, it dots the mid-island areas with its pale yellow flowers. By midsummer, the plant has withered and it is easily recognized by its black leaves.

Beach Evening Primrose (*Oenothera drummondii*)

Beach evening primrose is abundant throughout the summer, and the yellow, fading reddish flowers may be found open from evening to late morning. Fine, greyish white hairs cover its leaves. This woody-stemmed herb is widespread on the bay shores, mid-island areas, and on sandy coastal dunes.

Sea-purslane (*Sesuvium portulacastrum*)

Patches of sea-purslane are common on the otherwise sparsely vegetated beaches exposed to the danger of wave action. All parts of the plant are stout and fleshy. The flowers are solitary in the leaf axils and lack petals. The external green calyx lobes are pink-purple within.

Mr. Lee C. Otteni received his B.S. degree in Wildlife Management from New Mexico State University in 1969; and his M.S. degree in Range and Wildlife Management from Texas Tech in 1971, under a Rob and Bessie Welder Fellowship.

In July 1971 he joined a research project, now in its fifth year, on sand dune stabilization along the Gulf Coast.

He is a member of The Wildlife Society, Southwest Nautralists, Audubon Society, and the Wilson Ornithological Society.

COMMON FISH OF PADRE ISLAND

By Robert F. Travis*

COMMON NAMES	DISTINGUISHING CHARACTERISTICS	EDIBLE	WHEN & WHERE CAUGHT	BAIT & TACKLE	METHOD	TEXAS RECORD	HOW TO PREPARE	COMMENTS
Speckled Trout* Spotted Weakfish Speck Trout	Numerous small spots & one or two prominent front teeth	Excellent	Winter - Bay Shores & Shallows Summer Holes, cuts, passes & beach Spawning season is June & fish will be on mud flats	Live Shrimp Artificial plugs Plastic worms on light spinning tackle	Shrimp-tree float or use very small sinker Plugs–work well in cuts and on beach Worms–Jigging in holes or under lights	13 #2 oz.	Any method – excellent charcoal broiled or fried whole	This is the most popular game fish on the Texas coast
Sand Trout* Weakfish Sandys Trout	Similar to Speck but lacks spots	Good	Most frequently caught in canals, but inhabits all waters all year–common under permanent lights	Dead shrimp with very light tackle	Small sinker and treble hook on bottom	5 #12 oz.	Best if prepared immediately after catch using any method. Freezing is not recommended, but if necessary, freeze in water pack using old milk cartons, etc.	
Redfish* Reds Channel Bass	Prominent black spot near upper tail	Excellent to 10 lbs Good to 20 lbs Fair over 20 lbs	Summer surf, holes and canals Winter Laguna flats	Finger Mullet, Live & Dead shrimp, cut mullet, spoons, small crabs on light bait tackle or medium spinning tackle	3 to 4 oz sinker with #4 hook on bottom	51 #8 oz.	Broil filets with lemon & butter	If a 20 lb+ redfish is caught without serious injury to fish, true sportsmen replace fish to breed again.
Flounder* Flatfish	Flat, with both eyes on upper brown side–lower side is snow white	Excellent	Fish the cuts on moving tide, or beach near cuts on outgoing tide Sept. to Jan. best months	Live or dead shrimp on light tackle and a "Flounder rig"	Flounder rig consists of sliding ball sinker followed by a swivel & short leader, which allows bait to float slightly off bottom Cast out and retrieve slowly on bottom	8 #4 oz.	Excellent any method Best broiled whole	Flounder take the bait with a very light tap and then fight hard; therefore light tackle not only helps to feel strike, but offers great sport in catching
Pompano	Shape see drawing Yellow color near fins	Excellent	Jetties & piers into surf May to December	Small pieces of shelled shrimp small yellow and white jigs. Use strong small hooks.	Drop shrimp or jig to bottom, then flip a foot or so off bottom & let rest a while to imitate sand flea		This is the best inshore fish for eating and is usually reserved for gourmet dinners. Prepare in any manner.	Prepare for a fight.
Sheepshead	Teeth resemble sheep's; blackish and greyish vertical bands	Good	Piers & jetties	Small crabs; shrimp	Let bait hang along side piling and rocks off bottom		Filet & fry	
Gafftop Sail Catfish Gafftop*	Long dorsal fin and scum on tackle	Good	Almost anywhere; any time	Medium to heavy tackle and live or dead bait	Bottom fishing	9 #0 oz.	Filet, then skin and remove dark flesh on sides. This leaves a delicate white meat which is best fried	This is a hard fighting fish which can ruin light tackle. It will leave a slimy mucous which will cover terminal tackle and lower end of line.
Hardhead Catfish Sea Catfish Hardhead*	Long barbels on mouth	Not edible	These fish are so common and in so many places that it would not surprise the author to find one in his tub	The object is to keep these off your tackle			Do not eat	These saltwater pests are armed with sharp poisonous spines in their fins which inflict a painful wound if the angler is not careful when removing them
Whiting* Southern King Whiting Surf Whiting	Silver white color	Fair to good	Very common in surf all year	Live or dead bait on light tackle	Bottom fishing		Filet and fry	
Porgy* Pinfish	Colorful greens with longitudinal stripes	Fair	Very common in all water	Live or dead bait or very light tackle	Bottom fishing		Filet and fry	This fish is quite boney and although the flesh is good it requires more work than most fishermen are willing to put up with for a meal; therefore it has a poor reputation
Mullet	Green or silver Small mouth Big head	Fair	Most common fish seen in surf; seen in schools or jumping; caught with nets in surf and shallows	Cast net or seine			Not usually eaten in this country, but claimed to be delicacy by other countries	The author has eaten this fish fried whole and thought it to be good. However, most people consider this a bait fish only.

Spanish Mackerel	Smooth silver skin with gold spots	Excellent	Not commonly caught but appears near jetties and when water cleans up off piers in April to October	Jigs, Hooties and small spoons on light spinning tackle	Cast out and fast retrieve	7 #8 oz.	This excellent eating fish is considered one of the oily varieties and is best baked	This fish is a speedster and watching it take the bait is a real thrill
Pig fish Piggie*	Shape of head	Fair	See Porgy	See Porgy	See Porgy		See Porgy	See Porgy
Stingray Stingaree*	Shape and long tail	Fair	Mostly in cuts and canals	Caught in almost any manner using live or dead bait	This is one you really hope to miss		It has been claimed that this fish is cut into round plugs and sold as scallops. The author tried frying some small round plugs and found them adequate to prevent starvation, but a poor substitute for scallops	The barb about halfway down the tail can inflict a painful and serious wound which requires hospital care
Tarpon	Very large mouth	Not edible	Off piers April through September; Tarpon have become rare catches close in	Use live Mullet and heavy tackle	Drop Mullet about 2 to 3 feet beneath a float and let it free swim; wire or hook Mullet so as to cause little injury	192 #	This one is best mounted on the wall.	This fish offers the beach and pier fisherman a chance to enter the world of big game fishing.
Bluefish Blues*	Blue color; soft tail	Good	Surf in summer	Artificials on light or medium tackle	Cast and retrieve in almost any manner		Filet and fry or broil with lemon and butter	This is a Florida fish which usually migrates up the east coast; however, some migrate into the Gulf and appear off Texas sporadically. This is a voracious fish which literally attacks the bait and then fights hard.
Black Drum See comments for Drum	Vertical light grey and dark grey areas; many short barbells or beards	Good	Surf all year	Live and dead shrimp; small crabs; cut bait; light tackle	Bottom fishing		Filet and fry	Drum of larger species are found in Intercoastal Canal during spring. These go for small crabs and require heavy tackle
Croaker and Golden Croaker	The Croaker is noted for his incessant croaking when caught. The Golden Croaker is gold colored.	Good	Surf and cuts all year; Golden Croaker seem more plentiful in spring.	Live and dead shrimp; cut bait; light tackle	Bottom fishing		Filet and fry Croaker. Golden Croaker are considered by some to be excellent and can be prepared in any manner	
Sharks	Many sharp teeth	Some good; some fair; some not edible	Surf all year	Cut bait and heavy tackle	Bottom fishing		If edible, broiled as steaks, seems to be preferred way	Many small sharks roam the Texas surf. Most are harmless. Most are not edible. The exceptions to these rules are worth knowing. Sharks can be both dangerous and excellent to eat. See a more detailed book about fish for shark information.
Snook* Robalo Salt Water Pike	Pronounced black lateral stripe from above gill to center of tail	Good	Summer near jetties	Surface lure or live bait and medium or heavy tackle	"Puddling" move the bait on surface in figure 8 above or near spot fish is expected	57 #8 oz.	Broil filets	Piscatorial dynamite; averages 5 lbs., but will put wear and tear on light tackle
Spadefish	Long fins and sharp black and white vertical stripes	Good	Near obstructions in surf during summer	Light tackle and live or dead shrimp	Free floating or on bottom		Fry or broil filets	

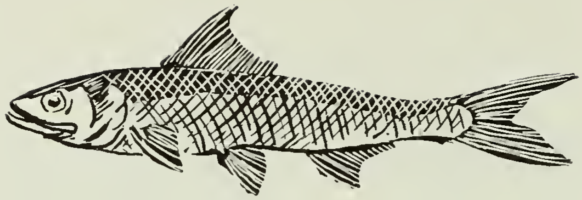
*Denotes most common name locally

***Employment:**
Geophysicist, Humble Oil & Refining Co., 1957 to 1961, New Orleans, Louisiana
Geologist, Sinclair and Atlantic Richfield Companies, 1961 to 1971 in Houston and Corpus Christi, Texas
Presently a geologist with the L. T. Burns Estate, Corpus Christi.

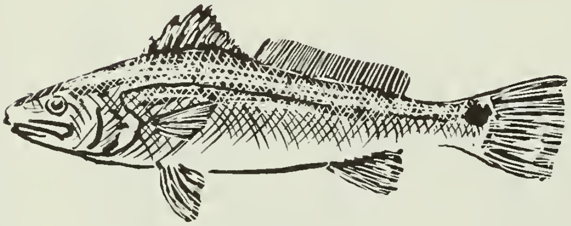
Education:
High school – Hawaii and Savannah, Georgia
College – University of Texas at Austin

As can be seen by the above employment and education record, most of Mr. Travis's adult life has been on one beach or another. This naturally led to an interest in fishing and other water sports as a pasttime. It is upon this experience and from conversations **with fishing friends that the preceding compilation is made.**

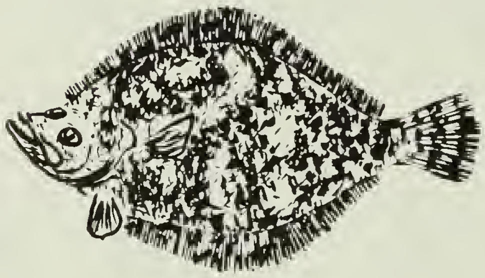
Spotted Weakfish or Speckled Trout
Cynoscion nebulosus



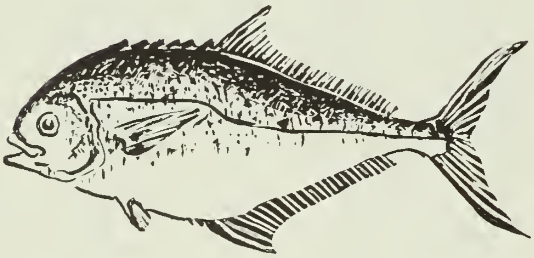
Ten-pounder, Skipjack or Ladyfish
Elops sarus



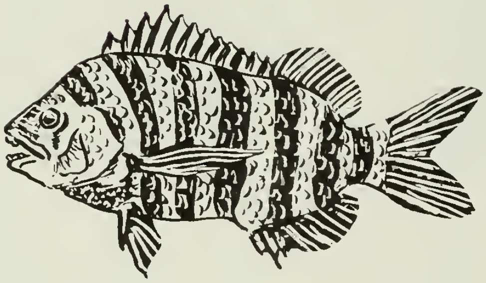
Channel Bass or Redfish
Sciaenopsocellata



Southern Flounder
Paralichthys lethostigma



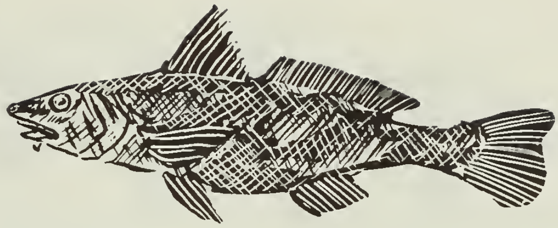
Pompano, Common
Trachinotus carolinus



Sheepshead
Archosargus probatocephalus

Gafftopsail Catfish
Bagre marina

Sea Catfish
Galeichthys felis



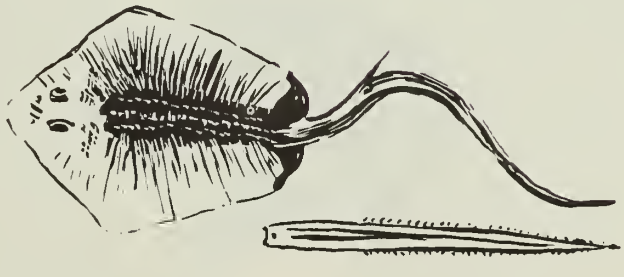
Southern King Whiting or Surf Whiting
Menticirrhus americanus

Pinfish, Saltwater Bream, Porgy
Lagodon rhomboides

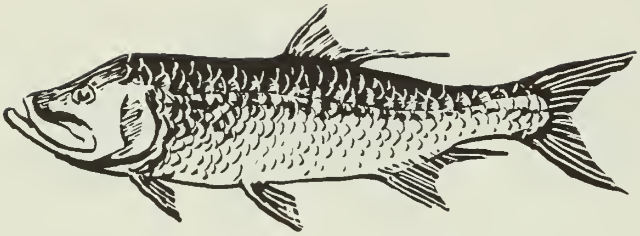
Mullet, White
Mugil curema

Spanish Mackerel
Scomberomorus sierra

Pigfish – Piggie, Hogfish
Orthopristis chrysopterus



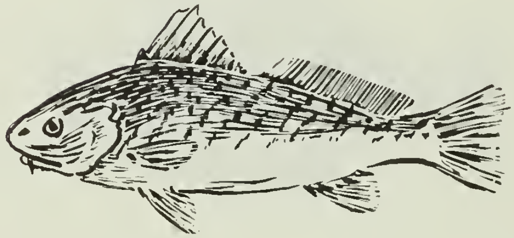
Stingray or Stingaree
Dosyatis sabina



Tarpon
Tarpon atlanticus

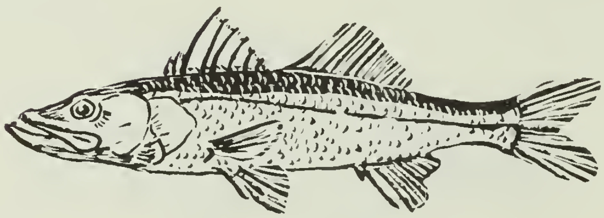
Bluefish
Pomatomus saltatrix

Black Drum
Pogonias cromis



Croaker
Micropogon undulatus

Shovel-nosed Shark
Sphyrna tiburo



Snook
Centropomis undecimalis

Spadefish
Chaetodipterus faber

COMMON SNAKES OF PADRE ISLAND

Patrick M. Burchfield, General Curator
Gladys Porter Zoo
Brownsville, Texas

The Padre Island National Seashore stands alone as one of the few remaining unspoiled shore lines in America. The Island is a place where we can take a fleeting glimpse of nature before it is changed by the whim of man. Hopefully, we will continue to protect this sanctuary from the onslaught of commercialization.

Almost anyone with even the slightest appreciation for nature can thrill at the sight of a soaring shorebird, or relate to the fleeing rabbit, yet on encountering a snake, the almost universal reaction is one of fright and dislike. It is this, the most misunderstood group of animals, we will briefly discuss.

Despite our "learned" fears of snakes, we must realize that like any of nature's creatures they occupy a niche and play an important role in maintaining nature's delicate balance. Even venomous snakes, such as rattlesnakes, are important in controlling harmful rodents, and when confronted by man, if given the opportunity will retreat not attack. Snakes are *reptiles*, a group which includes the Crocodilians, Lizards, Turtles, Tuataras and Snakes. All are cold-blooded, have a skin impervious to dehydration and produce shelled eggs or live young capable of survival away from water.

Hopefully, some of the facts in this brief paper will give you, the reader, a greater understanding of snakes and the way they live, and conceivably kindle an interest where fear once existed.

HOG-NOSED SNAKE
(Hererodon nasicus)

Blowing adder, blowing viper, spreading adder, spread-head are just a few of the many dangerous sounding names applied to the *harmless* Hog-nosed Snake. Nature has bestowed many tricks in protecting its creatures, the Hog-nosed Snake huffs, puffs, spreads the neck region in cobra like fashion, hisses loudly and strikes out in a truely frightening manner. Frequently this performance results in someone bashing in the snake's head and accounts for the widespread belief that these are a venomous species. Despite his awesome actions, the Hog-nosed Snake is quite *harmless* to humans. If his threatening fails, he then reverts to playing possum, by rolling over and playing dead. This sham so perfectly imitates death, that the snake bellies up with his mouth open and tongue loosely hanging out to one side. The muscles controlling the vent are relaxed allowing fecal material and uric acid to come out, a condition we see in dying animals. After a time, with the passing of danger, the snake very slowly cocks his head to check the area. If safe, he will flip right side up and crawl to safety. The snake is so convincing in his act that if you flip him right side up he will quickly roll over on his back again.

The western Hog-nosed Snake feeds on small rodents and lizards, but toads make up the largest portion of their diet. Upon finding a toad, the hog-nosed snake quickly grabs it. Immediately the toad inflates himself, making it seemingly impossible for the hog-nose to swallow him. The snake then uses yet another of his tricks, bringing into play two long toad-popping teeth located in the back of the upper jaws. Deflated, the toad becomes an easy meal.

Hog-nosed Snakes are oviparous, laying anywhere from five to twenty-four eggs in a clutch.

This snake's overall coloration is a buffy or creamy color with darker tan or brown blotches. When inverted, on the belly we see a shocking contrast between vivid red-orange, black, and white, in an interlacing series of parallel markings.

GLOSSY SNAKE
(Arizona elegans)

Named for the highly polished appearance of his smooth-scaled skin, the Glossy Snake is active during the day and feeds on lizards, small birds, and rodents, which it constricts. This snake is usually a creamy color with dark edged brown blotches down the back; sometimes we find specimens with a salmon or reddish hue to the body. The belly is unmarked and white or creamy.

When captured, it is normally docile, rarely offering to bite. Once in a while, an unusually agressive specimen is encountered. His body in loose coils and raising his head in an "S" loop, like a Western Diamondback Rattlesnake, the snake assumes a defensive posture.

The Glossy Snake is an egg layer, generally laying between six and twelve eggs. This snake rarely exceeds four feet in length.

WESTERN DIAMONDBACK RATTLESNAKE
(Crotalus atrox)

Vast tracts of rock, sand and sparse vegetation, this forbidding desolation is home to the Diamondback. The Western Diamondback is a wide ranging snake and is found in large numbers. Because of frequent encounters with man, the Western Diamondback bites more people each year than any other species of North American venemous snake. In some more northerly areas, large aggregations of rattle-snakes are found at denning sights where they spend the winter months. The Western Diamondback is the second largest venemous snake in the United States, reaching a maximum length of more than six and one half feet, rarely seven feet, and a weight of more than fifteen pounds. The overall body coloration of the Diamondback is a sandy gray or brown, with a series of darker edged brown diamond shaped markings down the back, terminating into a series of black and white alternating bands on the tail. Western Diamondbacks feed on a wide variety of small mammals, birds, and lizards. Although adults rarely would eat snakes, the babies of several species of rattlers in captivity readily cannibalize their brothers and sisters and "probably" would in nature as well, meals being few and far between and survival being the prime consideration.

The Diamondback belongs to a group of venemous snakes termed "Pit Vipers", so named for the presence of a

small opening on each side of the face beneath and between the eye and nostril. This pit is equipped with many heat sensitive nerve endings and aids the rattler in detecting body temperatures of intended prey animals. The rattlesnake possesses a highly specialized or modified saliva called venom. The venom is produced in glands on each side of the snake's head behind the eyes. A tube or duct runs from the venom glands into a special hollow tooth called a fang. The fangs are attached to movable bones and when at rest, are rotated into the roof of the snake's mouth. When striking, the snake opens the mouth, rotates the fangs 180 degrees into biting position. Venomous snakes with movable fangs are able to penetrate a flat surface. In biting, the rattler contracts the muscles surrounding the venom glands, sending the toxic fluid through the duct into the fangs and the punctures. Venomous snakes don't always inject venom in biting, and the quantity is variable.

The terms *venomous* and *poisonous* are used interchangably by many persons. However, many poisonous substances are not venoms. Venom is principally protein in nature, possessing many components of varied actions. The venom is used to disable, kill, and initiate the digestion of animals which the snake feeds on, as well as being an effective self-defense mechanism.

The rattle from which the snake derives its name is comprised of fingernail-like substance. Starting with a button at birth, the rattlesnake usually adds a segment to his rattle with each subsequent shedding of his old outer layer of skin.

The shedding process, "ecdysis", is linked with growth and repairing of injuries. If food is plentiful, the young snake will grow rapidly and shed frequently, adding two or three segments of rattle per year. On the contrary, if hunting is poor and food sparce, the snake may add only one or no segments in a season. As the rattle becomes long, it also becomes brittle and segments readily break off. The variable number of segments per year and breaking of the rattle make it virtually impossible to determine the rattlesnake's age. The segments of rattle loosely interlock and a rapid vibration of the tail produces the buzzing sound.

WESTERN MASSASAUGA RATTLESNAKE
(Sistrurus catenatus)

Ground Rattlesnakes, the "Massasaugas", and Pigmy Rattlers, seldom grow to more than thirty inches in length. Their generally dull colors, usually grey or brown, and obscure markings aid them in going unnoticed. This snake has a series of dark blotches down the center of the back with a second group of smaller blotches on each side where the sides join the belly. The belly, or ventral surface may show a row of faint blotches on each side. The rattle of these small snakes is barely audible.

Despite their diminutive size, the Pigmy and Ground Rattlesnakes have firey dispositions and surprisingly toxic venoms. Fortunately, because of their small size and small quantity injected, bites rarely could be potentially lethal.

Once aroused, the forked tongue of the Massasauga darts in and out. Like all of his serpentine brothers, his tongue is an implement of his sense of smell, the tongue comes out, picks up odorous particles and returns them to the roof of the mouth, where Jacobson's organ, (smell-taste), is located.

Smell is the snake's most important sense. They use it to detect food, water, determine enemies, and in the spring of the year, to locate females which extrude a scent trail for the male to follow.

Like the larger species of rattlesnakes, the Massasaugas have eggs which hatch internally, giving birth to living young. The young rattlesnakes are in possession of their venom apparatus at birth. Their venom is identical in potency to that of their parents, but obviously in quantity, making them less less dangerous.

WESTERN COACHWHIP SNAKE
(Masticophis flagellum)

Slimmer and longer than their near relatives, the Racers, the Coachwhips are among the fastest moving of snakes. The overall body coloration of this snake is a uniform tan occasionally with a pinkish tinge. In some areas it is called "prairie runner".

One popular snake story tells of Coachwhips entwining around humans and lashing them with their whip-like bodies. Quite adept and agile climbers, Coachwhips are frequently encountered in bushes and tree-tops hunting for birds and eggs.

The long, graceful serpentine body and fluid motion of the Coachwhip give the illusion of great speed. This snake grows to a length of more than six and one half feet. Coachwhips, like the Racers and other whipsnakes, feed on a wide variety of small lizards, birds, rodents and other snakes.

Large protruding eyes and keen eyesight are essential to this active hunter's existence. Body shape and the position and size of the eyes, tell us much about the habits of a species of snake. Obscured small eyes indicate a fossorial or burrowing existence; large eyes and graceful body shape, an active hunter. A short, chunky body generally indicates a snake that lies in wait to ambush his prey.

RIO GRANDE RACER
(Coluber constrictor)

Named for a sleek stream-lined body, the Racers are alert, fast moving predators. This species is a small Racer, seldom exceeding three feet in length. The coloration is blue-grey with a greenish cast, being darkest on the snake's back and becoming lighter on the sides and belly. The belly is a creamy color and unmarked. Racers feed on a wide variety of creatures including small mammals, frogs, birds, lizards, insects, snakes, and even on occasion, venomous snakes. Some species of snakes are known to be immune to venom, while many others not immune are highly resistant to venom when injected into muscle tissue.

Racers, being active hunters, have good eyesight and often can be seen raising up their heads, scanning the area in search of prey. Even the fastest moving snakes, the Coachwhips and Racers, are capable of speeds of only eight or less miles per hour. The average man is capable of running fifteen miles per hour, which casts great doubt on stories of *snakes* running down and attacking humans. Possibly the ease with which snakes glide through even dense underbrush gives rise to exaggerations of speed with which they move.

Once a prey animal is sighted, the Racer stalks slowly and deliberately, inching closer and closer. With a sudden burst

of speed, he grabs his prey. Lacking venom or powerful constricting coils, the Racer thrashes his head from side to side dashing the animal on the ground or a rock. The stunned animal will suffocate in the snake's stomach.

Small, more helpless animals may be swallowed literally "alive and kicking" and can be seen kicking inside the snake en route to the stomach. Racers are egg-layers, the young being highly patterned, the pattern becoming obscure as the snake becomes an adult.

MARCY'S GARTERSNAKE
(Thamnophis marcianus)

Probably the most familiar of all groups of snakes in the United States, the Gartersnakes are known to almost every child that has ever hiked a field or taken a walk in the woods.

The overall ground color of this snake is a light olive, sharply divided by a fine yellow stripe down the middle of the back. On each side of the stripe we find three alternating rows of small irregular edged spots, giving the snake a checkerboard appearance. The belly usually is unmarked.

Gartersnakes are active hunters which feed on a wide variety of frogs, small mammals, lizards, fish, earthworms and many other items. Primarily nocturnal, gartersnakes can frequently be encountered at dawn or dusk going out to or returning from hunting. In much of the arid range of this snake, we find him particularly active during the infrequent rains, taking advantage of the abundance of amphibians as food. Gartersnakes are ovoviviparous, the live young generally more than a dozen in number.

A wide variety of animals are predacious on Gartersnakes, such as coyotes, opossums, racoons, skunks, owls and a variety of hawks.

Some other types of snakes a person might encounter on the island may include the:

Rough Green Snake *(Opheodrys aestivus)*
Mexican Milk Snake *(Lampropeltis triangulum)*
Texas Coral Snake *(Micrurus fulvius)*
Emory's Rat Snake *(Elaphe guttata)*
Texas Bull Snake *(Pituophis melanoleucus)*
Texas Indigo Snake *(Drymarchon corais)*
Texas Patch-nosed Snake *(Salvadora lineata)*

as well as a variety of additional smaller forms.

RECOMMENDED READING

Klauber, Laurence M.
Rattlesnakes: Their Habits, Life Histories, and Influence on Mankind.
University of California Press, Berkley, California.

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The Peterson Field Guide Series, Houghton Mifflin Co., Boston, Mass.

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1958, *A Field Guide to Reptiles and Amphibians of the United States and Canada East of the 100th Meridian.*
The Peterson Field Guide Series, Houghton Mifflin Co., Boston, Mass.

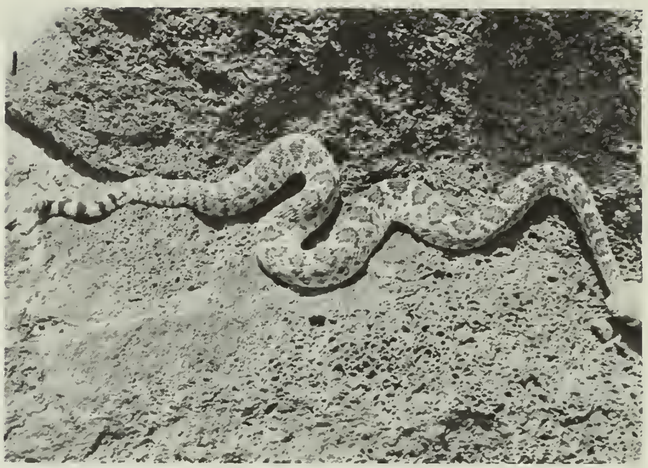
Brown, Bryce C.
1950, *An Annotated Checklist of the Reptiles and Amphibians of Texas.*
Baylor University Press, Waco, Texas

Mr. Patrick M. Burchfield graduated from North High School, Columbus, Ohio, and attended Ohio State University. He worked 5½ years as keeper and head keeper in the Reptile Department, Columbus Zoo, and 3½ years as Curator of the Serpentarium at the Army Medical Research Laboratory, Fort Knox, Kentucky. He is now General Curator and Herpetologist at the Gladys Porter Zoo, Brownsville, Texas.

WESTERN HOG-NOSED SNAKE

WESTERN HOG-NOSED SNAKE
"Playing Dead"

GLOSSY SNAKE

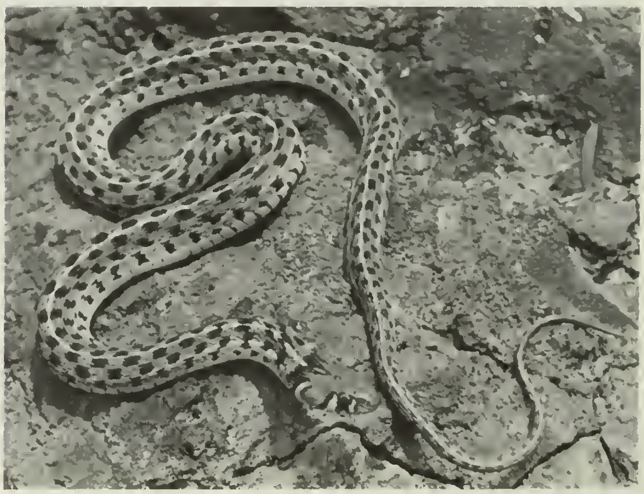


WESTERN DIAMONDBACK RATTLESNAKE

WESTERN MASSASAUGA RATTLESNAKE

WESTERN COACHWHIP SNAKE

RIO GRANDE RACER



MARCY'S GARTER SNAKE

THE MAMMALS OF PADRE ISLAND

Dr. Warren D. Thomas
Director, Gladys Porter Zoo
Brownsville, Texas

Padre Island lies as an unusual land feature off the mainland Texas Coast. It can be likened to an oblong, slender, double seashore with primary marine wave action on the seaward side, and secondary marine wave action on the leeward or bay side. Geographically, it acts as a buffer to the mainland Texas Coast. Therefore, the dynamics of the bay side of the Island are almost identical to the mainland Coast, on the opposite side of the bay running parallel to Padre Island. It is best described as a desert virtually without fresh water, and with minimal vegetation. Most of the mainland mammalian forms are found only as occasional or accidental visitors.

There are relatively few permanent mammalian residents. Although, along with the rapidly changing face of the Island by man, there has been a marked increase in recent years of permanent inhabitants, primarily because man has brought fresh water and available food supplies which did not exist before. So, we see opportunistic invaders in the nature of those that accompany man wherever he goes, such as the Norway Rat, the house mouse, the feral dog and feral cat. It is unnecessary to dwell on the habits of these, the satellites of man. Their habits and characteristics are well known.

We will concern ourselves, then, with those native inhabitants and occasional visitors which are part of Padre Island's fauna. The permanent residents are those which can cope with the desert-like environment, such as small populations of ground squirrels, South Texas Pocket Gophers, Grasshopper Mice, and White-Footed Mice. These small rodent populations are not enough to support any quantity of dependent carnivores, but rather are preyed upon by the occasional mainland visitor. Populations are held in check from excessive increases in numbers by the very limited food and water supply. In addition, the occasional storms further add to hardships and attrition by the drowning out of populations. All things considered, Padre Island is, at best, characterized as being a very hostile and inhospitable environment for most mammals, with the exception of man, who takes his environment with him.

The following are two check lists of animals known to be permanent residents, and those that are short-term residents, occasional or accidental visitors:

PERMANENT RESIDENTS

EASTERN MOLE *(Scalopus aquaticus)*

Description: This burrowing mammal is best recognized by its shovel-like front feet, and very soft, short fur; dark brown in color and generally giving the appearance of being a very compact, robust animal. Its total length rarely exceeds 165 mm; total weight: between 60 and 100 g.

Habits: They are almost totally underground inhabitants; very rarely found on the surface. If found in any numbers on Padre Island, they are more likely to be encountered in the broad, thickest portions of the Island that are the highest and driest.

LONG-TAIL WEASEL *(Mustela frenata)*

Description: The Long-Tail Weasel is quickly identified by its long, slender, almost serpentine body. Its movements are quick and fluid. The form most commonly encountered here has a rich, medium brown color on the shoulders and back, with cream-colored markings on the abdomen and across the head. The eyes are set into a hair pattern that is almost mask-like. The overall length is roughly 450 to 500 mm; weight: 300-500 g.

MEXICAN GROUND SQUIRREL *(Spermophilus mexicanus)*

Description: This is a small ground squirrel with a light tan hair coat, marked by nine rows of white spots down the back.

Habits: An occasional resident of the southern third of Padre Island, it exists with some difficulty due to the poor ground cover and scarcity of food.

SPOTTED GROUND SQUIRREL *(Spermophilus spilosoma)*

Description: This is a small ground squirrel with a scattering of white spots on a light brown background. The spots show in no definite order, unlike those of the Mexican Ground Squirrel. The total length is 210 to 225 mm; weight: from 100 to 130 g.

Habits: It tends to be more restricted to the northern half of Padre Island. It prefers dry, sandy soil and appears to adjust to the Padre Island environment much better than the Mexican Ground Squirrel.

SOUTH TEXAS POCKET GOPHER *(Geomys gersontus)*

Description: Compared to the other burrowing mammals, the South Texas Pocket Gopher is one of the largest. Its color is pale brown to greyish, drab in appearance, with fairly long, but very scant hair distribution over its tail. The incisors, unlike those of the ground squirrel, are grooved. Length is about 325 mm; weight: up to 400 g.

Habits: This burrowing rodent is one of the most successful inhabitants of Padre Island. It is found in the central portion of the Island and its burrows are extensive in the northern portion of the Island. Burrows over 100 feet long have been excavated, demonstrating this animal's prodigious burrowing qualities.

SPINEY MOUSE *(Liomys irroratus)*

Description: The Spiney Mouse is a medium-sized mouse with a very coarse haircoat, the individual hairs being so coarse as to give it an almost hairbrush look; hence the name. Its color is brownish above, with whitish under-

parts. Its total length is 230 to 245 mm; weight: 35 to 60 g.

Habits: It tends to be found in the highest concentration in the southern half of Padre Island.

MERRIAM POCKET MOUSE *(Perognathus merriami)*

Description: This very small mouse is almost the antithesis of the Spiney Mouse in the quality of its haircoat. The haircoat is as soft as the Spiney Mouse's is harsh. The upper color is an ocher-brown, mixed with long, black guard hairs, whitish underneath. Its total length is 110 to 120 mm; weight: 7 to 9 g.

Habits: This tiny rodent is often overlooked because of its diminutive size. It does reasonably well in the parts of the Island that have the highest elevations. It is unusual for a wild rodent in that it has a surprising tolerance of man. It is often picked up and makes no attempt to bite. . . unusual for any wild rodent.

SHORT-TAILED GRASSHOPPER MOUSE *(Onychomys leucogaster)*

Description: This fairly large, heavy-bodied rodent, with its dun grey to cinnamon upper parts, fading into pure white underparts, is generally found in sizes ranging from 130 to 164 mm, and weights from 27 to 52 g.

Habits: This predatory mouse, as it has often been called, is a great benefactor of man in that it kills and eats great quantities of insects and spider pests. It eats some vegetation, but its diet consists mostly of insects. Similar to the Pocket Mouse, it shows great docility.

WHITE-FOOTED MOUSE *(Peromyscus leucopus texanus)*

Description: The White-Footed Mouse is one of the most common medium-sized rodents in the State of Texas. Its color ranges from dark cinnamon brown to rufus above, with dark guard hairs and a pure white coloration on the underparts of the feet. Average length is 173 mm; weight: 18 to 32 g.

Habits: Its range encompasses all of Padre Island; although it is not a successful permanent resident, it does manage to survive. It is usually found in small populations.

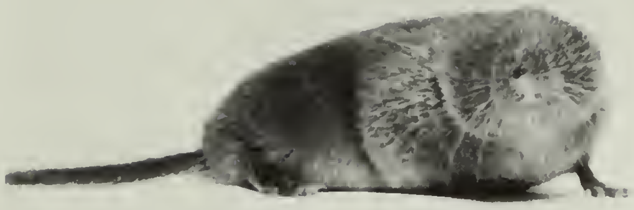
OCCASIONAL VISITORS, SHORT-TERM RESIDENTS OR ACCIDENTAL INHABITANTS

Little Short-tailed Shrew *(Cryptotis parva)*
Crawford Shrew *(Notiosorex crawfordi)*
Georgia Bat *(Pipistrellus subflavus)*
Hoary Bat *(Lasiurus cinereus)*
Red Bat *(Lasiurus borealis)*
Yellow Bat *(Lasiurus intermedius)*
Evening Bat *(Nycticeius humeralis)*
Guano Bat *(Tadarida mexicana)*
Raccoon *(Procyon lotor)*
Spotted Skunk *(Spilogale putorius)*
Striped Skunk *(Mephitis mephitis)*
Badger *(Taxidea taxus)*
Coyote *(Canis latrans)*
Hispid Pocket Mouse *(Perognathus hispidus)*
Ord Kangaroo Rat *(N.) Dipodomys ordii largus, (S.) D.o. compactus*
Pygmy Mouse *(Baiomys taylori)*
Hispid Cotton Rat *(Sigmodon hispidus)*
Grey Wood Rat *(Neotoma micropus)*
Nutria *(Myocastor coypus)*
California Jack Rabbit *(Sylvilagus floridànus)*
Nine-Banded Armadillo *(Dasypus novemcinctus)*

Suggested reading:

1. MAMMALS OF NORTH AMERICA – 2 Vol.
   E. Raymond Hall, Keith R. Kelson
   Ronald Press Co., New York, 1959
2. LIVES OF GAME ANIMALS – 4 Vols.
   Ernest Thompson Seton
   Chas. T. Branford Co., Boston, 1953
3. WILD ANIMALS OF NORTH AMERICA
   National Geographic Society, Washington, D.C., 1960
4. FIELD GUIDE TO THE MAMMALS
   Peterson Field Guide Series
   W. H. Burt, R. P. Grossenheider
   Houghton Mifflin Co., Boston, 1952
5. THE MAMMALS OF TEXAS, Bulletin 41
   William B. Davis
   Texas Parks & Wildlife Dept.
   Austin, Texas, 1966

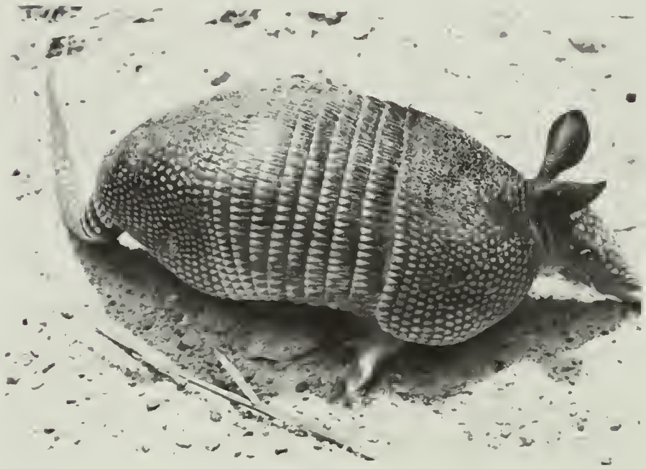
Dr. Warren D. Thomas, born November 27, 1930, Columbus, Ohio; educated in Ohio public schools, graduated from Ohio State University, Columbus, Ohio, with a Degree of Bachelor of Science and also with a Degree of Doctor of Veterinary Medicine, Omaha, Nebraska, Assistant Professor of Internal Medicine; and at University of Nebraska College of Medicine, Omaha, Nebraska, Assistant Professor of Research Medicine. Keeper at the Columbus Municipal Zoo; Consultant for the Jardin Zoologico de Barranco in Lima, Peru; Director of the Oklahoma City Zoo, Oklahoma City, Oklahoma; and Director of the Henry Doorly Zoo, Omaha, Nebraska until coming to Brownsville. Dr. Thomas served as consultant to zoos in the United States and abroad. He has also served as guest lecturer on educational television and is the author of numerous scientific publications. He is married and has one son and two daughters.



CRAWFORD SHREW

COYOTE

HISPID COTTON RAT



NINE-BANDED ARMADILLO

WHITE-FOOTED MOUSE

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